Enhancing Transportation Project Delivery Through Watershed Characterization

Operational Draft Methods Document

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This is a working document and as such contains material subject to change. Comments on the material may be sent to the address below for consideration during future updates.

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List of Acronyms and Abbreviations

303(d)	List of impaired waterbodies specified in the Clean Water Act, Section 303(d)
ADT	Average daily traffic
B-IBI	Benthic – Index of Biological Integrity
DAU	Drainage Analysis Unit
DBH	Diameter breast height
DEM	Digital Elevation Model
Ecology	Washington State Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EIA	Effective Impervious Area
EMC	Event mean concentration
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESB	Engrossed Senate Bill
ESM	Ecology’s Stormwater Management Manual for Western Washington
FEMA	Federal Emergency Management Agency
FRAGSTATS	FRAGSTATS is a computer software program designed to compute a wide variety of landscape metrics
GIS	Geographical Information System
GLO	General Land Office
HRM	Highway Runoff Manual
HSPF	Hydrological Simulation Program—Fortran
I-405	Interstate 405
LID	Low Impact Development
LiDAR	Light Detecting and Ranging

LWD	Large Woody Debris
NEPA	National Environmental Protection Act
PAH	Polynuclear aromatic hydrocarbons
PHS	Priority Habitats and Species
SEPA	State Environmental Protection Act
SR	State Route
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment Program
TIA	Total Impervious Area
TMDL	Total Maximum Daily Load
TPEAC	Transportation Permit Efficiency and Accountability Committee
TSS	Total Suspended Solids
USDA	US Department of Agriculture
USGS	US Geological Survey
WAC	Washington Administrative Code
WADNR	Washington Department of Natural Resources
Watershed Subcommittee	Watershed-based Mitigation Subcommittee of the Transportation Permit Efficiency and Accountability Committee
WDFW	Washington State Department of Fish and Wildlife
WRIA	Water Resource Inventory Area as defined in Chapter 173-500 WAC
WSDOT	Washington State Department of Transportation
WWHM	Western Washington Hydrologic Model

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Executive Summary

Introduction and Overview

This report summarizes a scientific framework and set of procedures being developed at multiple watershed scales to identify and prioritize sites having potential to mitigate transportation impacts. The main body of this report presents methods for watershed characterization, while the case studies that were used to develop methods are attached as case studies.

Continued decline in the health of aquatic ecosystems, and the species associated with them, indicates that something is dramatically wrong with our approach to resource mitigation and management. Natural resource agencies are beginning to question the effectiveness of traditional mitigation techniques, which perpetuate a narrow "project by project" or "on-site" review and analysis. This focus can lead to mitigation that treats symptoms of resource degradation rather than addressing core causes. To reverse this, new innovative strategies and methods are needed to more effectively assess and mitigate impacts.

Traditional mitigation techniques can lead to mitigation that treats symptoms of resource degradation rather than addressing core causes. To reverse this, new innovative strategies and methods are needed to more effectively assess and mitigate impacts.

Washington's Environmental Permit Streamlining Act (2001) creates an interagency Transportation Permit Efficiency and Accountability Committee that focuses on achieving both the transportation and environmental goals of the state, while expediting the environmental regulatory processes. The "Watershed-Based Mitigation Subcommittee" was created as part of this legislation and charged with developing a watershed approach to environmental mitigation for transportation projects. This report is the product of an interdisciplinary technical team working in close communication with the watershed subcommittee.

Watershed-based Methods

Watershed-based methods will be most effective when the approach is driven by landscape need and condition rather than an individual transportation project. The approach uses existing transportation planning documents to identify projects having the greatest need as well as sensitive landscapes that could most benefit from watershed characterization. Case Study 1 serves as an interim step toward this long-term approach, is project-driven, and focuses exclusively on testing and developing landscape methods. Case Study 2 focuses on further testing landscape methods in a real-world setting, producing timely results that may be used by the project team. Case Study 3 focused on more testing, using the process to address multiple transportation projects, and adding new analyses that addressed issues related to fish habitat and upland habitat connectivity. Additional projects will help to refine the methods, evaluate products in light of data needs for National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) documentation, implement mitigation options, and transition from a project-driven to landscape-driven approach to assessing transportation project impacts.

Watershed characterization methods seek to more completely understand project effects, assess the condition of surrounding natural resources, and identify potential mitigation options that have the greatest opportunity for maximizing environmental benefit while reducing mitigation cost. A set of guiding principles is presented to guide and direct methods development. To maximize environmental benefit, the focus of recovery efforts is on recovery of ecosystem processes. In Western Washington, key ecological processes are assumed to be the delivery and routing of water, sediment, pollutants, large wood, and heat.

Understanding the effects of transportation and surrounding land use impacts on ecological processes requires the formation of an interdisciplinary technical team. At a minimum, the team should consist of a hydrologist, hydrogeologist, ecologist, biologist, and water quality specialist. It is essential that this team have full access to Geographical Information Systems staff, tools, and spatial data.

Incorporating local watershed planning efforts early in the assessment process creates additional opportunities for the collection of locally developed data. Locally determined recovery priorities will be used for mitigation when they satisfy mitigation needs and fall within targeted recovery areas. Additionally, locally identified themes are used in the site prioritization process.

Not all transportation projects warrant the use of a watershed-based analysis tool. Until specific selection criteria are established, it is assumed that the watershed characterization tools are best suited to projects located in an urban or urbanizing area, have substantial potential to impact important natural resources, and extend across a large and diverse landscape area.

Assessment Framework

This approach outlines a scientific framework and set of procedures for identifying, screening, and prioritizing a suite of options capable of mitigating environmental impacts. The scientific framework is being developed within the following three assessment categories, each including a series of generalized steps that form the scientific framework for watershed characterization:

Part I: Watershed characterization and cumulative impact assessment – characterizing effects of land use on ecological processes and aquatic and terrestrial resources

Part II: Project site assessment – understanding the project’s potential environmental impacts

Part III: Identification and assessment of potential sites – ranking potential mitigation sites and selecting the preferred mitigation sites

Case Studies

Case Study 1 aided in developing key parts of this methodology by applying it to a project on State Route 522 near Monroe, Washington. The methods document has been updated since the completion of Case Study 1 and the order of the steps has changed.

Case Study 2 was used to refine this methodology as well as test it in a real-world setting, a section of Interstate 405 near to a project on State Route 522 near Renton, Washington. Again, we have updated the methods since this study and the order of the steps has changed.

Case Study 3 was used to further refine the methodology by adding new analyses that addressed issues related to fish habitat and upland habitat connectivity. It also tested the use of the watershed characterization process to address multiple transportation projects.

Introduction

Summary

This report summarizes a scientific framework and set of procedures developed at the watershed scale to assist in the screening and prioritization of sites having potential to mitigate transportation impacts. This report represents four distinct products.

1. It presents a conceptual framework for the landscape-scale characterization of transportation project environmental impact assessment and mitigation.

   As a conceptual framework, this document serves as the key deliverable to the US Federal Highway Administration summarizing watershed characterization methods and developing key recommendations that other transportation agencies can use to help meet future environmental assessment and mitigation needs.

2. It presents results of initial watershed characterization work in an attached volume.

   An initial watershed characterization addressed a test project on State Route (SR) 522 and provided recommendations to the Transportation Permit Efficiency and Accountability Committee (TPEAC) and Washington State Department of Transportation (WSDOT) on future actions needed to maximize lessons learned.

> ***A growing body of work indicates that declines in ecosystem integrity are perpetuated by existing policies and traditional techniques that tend to treat local symptoms of resource degradation and fail to address the root biological and physical causes of ecosystem degradation and population decline.***

3. It presents results of a more complete “real-world” watershed characterization test in an attached volume.

   The methods were given a more complete “real-world” test on the North Renton stretch of Interstate 405 (I-405). The results of this test were added as Case Study 2 in February, 2004. The list of potential mitigation sites was presented to the Urban Corridor Office to be used in the process of selecting mitigation sites for the project. The lessons learned from the I-405 test were used to update this methodology.

4. It presents results of a full scale, multi-project watershed characterization in an attached volume.

   The methods were used on an in-depth analysis, completed in early 2004, related to the Bellevue to Bothell stretch of I-405. Another even more in-depth analysis was completed in November, 2004, addressing the stretch of SR-520 from Lake Washington to SR-202. A list of potential mitigation sites was presented to the Urban Corridor Office to be used in the process of selecting mitigation sites for these and other projects. The lessons learned from this third study were used to further update this methodology.

The Problem

Despite dramatic increases in effort, legal mandates, and expenditures for environmental protection and restoration over the past 20 years, the overall condition of natural ecosystems continues to decline (Karr 1995, Montgomery et al. 1995). A growing body of work indicates that declines in ecosystem integrity are perpetuated by existing policies and traditional techniques that tend to treat local symptoms of resource degradation and fail to address the root biological and physical causes of ecosystem degradation and population decline. Further, regulatory agencies are beginning to question the effectiveness of traditional in right-of-way mitigation (Mockler 1998).

These policy and traditional techniques perpetuate a narrow "project by project" and "on-site" review and analysis that often results in mitigation that treats symptoms of localized habitat/resource degradation rather than addressing the systemic causes of ecosystem degradation (Frissell 1996, Angermeier and Schlosser 1995, Montgomery et al. 1995, Reeves et al. 1995, Ebersole et al. 1997). ***In many cases, traditional mitigation techniques have resulted in ineffective mitigation sites at very high costs.***

Background

The Clean Water Act, the Endangered Species Act (ESA) and NEPA represent cornerstone federal legislation to maintain human health, safety, and quality of life, while protecting the environment. These Acts, along with many companion state and local laws, require transportation projects to evaluate and mitigate adverse effects to water quality and quantity, ESA listed species, and natural resources. Past policy decisions, regarding the need for or preference of in right-of-way mitigation, have restricted opportunities to explore a broader range of mitigation options. It is becoming more apparent that we have reached our technical limits for in right-of-way mitigation in many instances. Mitigating stormwater impacts from a two-lane highway with 30,000 average daily trips is manageable under most situations. However, in many parts of the United States, transportation departments are faced with mitigating stormwater, wetland, and other natural resource impacts from a six-lane highway with 125,000 average daily trips that is surrounded by an urban landscape and land that is valued by the square foot, rather than the acre. This is the reality that WSDOT is facing in the metropolitan areas of Puget Sound. Further, some landscapes physically preclude mitigation within transportation project right-of-way. For example, stormwater retention for highways within floodplain areas is not practicable in many cases, due to flooding and high water tables. ***To meet our legal obligation to federal, state, and local law, it is imperative that new innovative strategies and methods be developed that effectively mitigate transportation impacts at the most appropriate and effective scale or scales.***

Transportation agencies across the United States have experienced an increase in environmental regulation and even greater increases in the cost of environmental mitigation over the last two decades. Rather than stabilizing, the trend seems to be escalating as land values skyrocket in urbanizing areas, more species are listed as threatened and endangered, and more water bodies fail to meet water quality standards. Progressive transportation agencies are beginning to explore innovative watershed-based tools that seek to address these issues by achieving greater permit predictability while increasing environmental benefits and reducing mitigation costs.

Transportation Permit Efficiency and Accountability Committee

In May 2001, the Washington State Legislature passed Engrossed Senate Bill (ESB) 6188, the Environmental Permit Streamlining Act (Revised Code of Washington, Chapter 47.06) to streamline environmental permitting processes for transportation projects. The bill creates TPEAC, a committee with interagency and legislative representation, responsible for creating a sustained focus on achieving both the transportation and environmental goals of the state while expediting environmental regulatory processes. TPEAC created six subcommittees to comprehensively address permit streamlining:

- Programmatic Process
- One-Stop Permitting
- Watershed-based Mitigation
- Planning
- Compliance, Training and Reporting
- Pilot Projects

The Watershed Subcommittee

ESB 6188 directed TPEAC to undertake the following activities to develop a watershed approach to environmental mitigation:

- Develop methodologies for analyzing environmental impacts and applying compensatory mitigation consistent with a watershed-based approach before final design, including least cost methodology and low-impact development methodology;
- Assess models to collate and access watershed data to support early agency involvement in transportation planning and review under NEPA; and
- Use existing best available information from watershed planning efforts, lead entities, regional fisheries enhancement groups, and other recognized entities as deemed appropriate by the committee, to determine potential mitigation requirements for projects within a watershed. Priority consideration should be given to the use of the state's alternative mitigation policy guidance to best link transportation mitigation needs with local watershed and lead entity project lists.

In September 2001, the Watershed-based Mitigation Subcommittee (Watershed Subcommittee) was formed and assigned these tasks.

In April 2002, the Watershed Subcommittee presented TPEAC with a conceptual framework for watershed-based mitigation planning. Working with the Federal Highway Administration and other federal and state agencies, WSDOT assembled an interdisciplinary technical team to develop, test, and evaluate watershed-based mitigation methods for a three-mile segment of SR-522 safety and improvement project in Snohomish County, Washington. The results of that test, completed in January 2003, are presented as Case Study 1. The first draft of this methods document was completed simultaneously with the SR-522 test, and drew heavily on the lessons learned during the test.

In March, 2003, the Watershed Subcommittee selected a planned project to increase mobility on the seven-mile North Renton stretch of I-405 as the second use of the methodology. This test was intended to be a "real-world" test of a project that was in progress. It was started far enough in advance to allow the results to be available to the project team to use in selecting mitigation sites. If the reader wishes to see this original draft for any reason, please contact the authors for an electronic copy.

> ***A conventional site-specific approach to environmental protection and recovery has failed to stem the decline in water quality, baseflow, fish and wildlife habitat at landscape scales, despite the expenditure of hundreds of millions of dollars on required mitigation and voluntary recovery efforts.***

The methods document was updated immediately upon completion of the I-405 test, and again drew heavily on the lessons learned during the test. The general methodology was quite similar but many details were changed. Most significant was that the order was changed substantially. There are both refinements and simplifications where appropriate. Again, if the reader wishes to see this draft for any reason, please contact the authors for an electronic copy.

The version of the methods document you are now reading was updated immediately upon completion of the second I-405 watershed characterization project. The general methodology was not substantially changed from the last version, though again there are refinements and simplifications where appropriate. Most significant is that several new steps have been added addressing upland habitat connectivity and other issues.

The Opportunity

The TPEAC process provides substantial opportunity to blend developing watershed approaches with new modeling and assessment tools to develop outcome-based approaches that transportation agencies and other organizations can apply when mitigating unavoidable impacts. However, good technical tools go unused if they are not assimilated into the existing planning and design process. The TPEAC process also provides the opportunity to design and implement an approach that strategically integrates a watershed approach to environmental mitigation into the project planning and design process.

The Need For a Watershed Approach

Watershed tools to identify core environmental problems and target mitigation actions are needed.

A conventional site-specific approach to environmental protection and recovery has failed to stem the decline in water quality, baseflow, fish and wildlife habitat at landscape scales, despite the expenditure of hundreds of millions of dollars on required mitigation and voluntary recovery efforts.

Clearly, the scale of assessment is not the only factor in this decline, but it appears to be a key one. There is a growing awareness that the scale of assessment needs to, at least initially, match the scale of the problem (Naiman et al. 1992, Doppelt et al. 1993, Montgomery 1995, Frissell and Doppelt 1996). If water quality problems are associated with one identifiable point-source, then a site-specific scale of assessment is appropriate. However, if water quality problems are associated with many non-point sources of pollutants distributed throughout a watershed, then a watershed-scale assessment is needed to identify, understand, and prioritize recovery options. A watershed approach has potential to provide a more flexible, less prescriptive process for achieving natural resource goals by targeting mitigation efforts to areas that have the greatest potential to address core environmental problems.

Watershed tools are needed to develop a landscape-scale understanding of human effects on ecological processes.

Natural systems are complex. Understanding cause and effect relationships within a very complex natural system will be key to realizing measurable success in environmental recovery. Discerning how present, past, and future land use affects physical agents of landscape pattern formation and maintenance will be an essential part of understanding cause and effect relationships and identifying core environmental problems. Navigating through this complex maze of human land use impacts and associated symptoms of environmental degradation will require watershed tools that help us understand the inter-related nature of natural systems.

Watershed-scale tools provide a mechanism for assessing landscapes.

Watershed-scale tools help us to focus on the parts of the watershed that provide potential mitigation options that maximize long-term environmental benefit at reduced cost. Opportunities for mitigating unavoidable transportation impacts can be numerous in some areas and nearly non-existent, in others. Available mitigation opportunities are dependent on location and extent of natural resources and past, present, and future land use. Watershed characterization tools can be used to rapidly assess where potential mitigation opportunities exist over large areas and where mitigation benefits are maximized.

A watershed approach can increase the probability that projects are delivered on time.

While project delays are often blamed on the environmental review process, those delays can result, in part, because the environmental assessment and review process occurs late in the project planning and design process. By moving watershed characterization to the earliest stages of project planning, this approach has potential to improve predictability in the environmental review process and reduce project delays. Further, this approach is being developed to target areas that are capable of mitigating transportation impacts, increasing overall environmental benefit, and reducing cost.

Finally, watershed-scale tools and a focus on restoring ecological processes increases potential for providing mitigation options that have the greatest opportunity to restore and maintain natural resource functions over the long-term.

Permitting agencies generally focus mitigation on area and function for regulated resources such as wetlands, floodplains, and riparian systems. Existing techniques assess function by evaluating structure (for example, percent emergent, scrub-shrub, and forested wetland, number of snags per acre, wetland has surface water outlet to a stream), so the tendency is to design the needed structural elements into a mitigation site. This approach has been successful at getting an acceptable function assessment score, but often times unsuccessful at creating a self maintaining natural resource. For example, placing three tree snags per acre in a created wetland may meet the structural criteria for raptor habitat, but when a wind storm topples the snags, the site is incapable of maintaining that function. Restoring structure may provide function in the short-term, but it is rarely self-maintaining. Restoring processes means planting the appropriate native trees in the proper microhabitats so that they are capable of growing, maturing, dying to create snags, and naturally replacing snags as they rot and fall. Restoring ecological processes creates the structure that results in functions having the greatest potential to be self-maintaining.

Short- and Long-term Approaches to Characterization

Developing watershed-based methods for assessing and mitigating transportation impacts is a complex, long-term endeavor. In light of this, the Watershed Subcommittee recognizes the need for staging method development and implementation into short- and long-term approaches. In the short-term, the subcommittee supports a project-driven approach to facilitate methods development (Figure 1). This approach takes an existing transportation project having already completed on-site project impact assessment to expedite and facilitate watershed characterization methods development. The SR 522 project used for the initial test case was selected because the project met this short-term need.

The subcommittee also recognizes the potential opportunities that exist to further increase environmental benefit if method implementation moves to a long-term approach driven by landscape need and condition rather than an individual transportation project (Figure 1). Our long-term approach will explore using existing 6-year and 20-year transportation planning documents to identify projects having the greatest need as well as sensitive landscapes that could benefit most from watershed characterization. The initial SR-522 study focuses exclusively on developing landscape methods outlined in the short-term approach. The second watershed characterization study, I-405 North Renton, refined methods development and began to explore opportunities and methods needed to migrate to the long-term landscape-driven approach to assessing transportation project impacts.

Another important long-term goal of WSDOT staff and the subcommittee is to address multiple transportation projects in each watershed characterization study. This was addressed in the third project undertaken, which addressed three proposed projects on I-405 and three more on SR-520. The study area also encompassed many other state highways which could benefit from the results of the study.

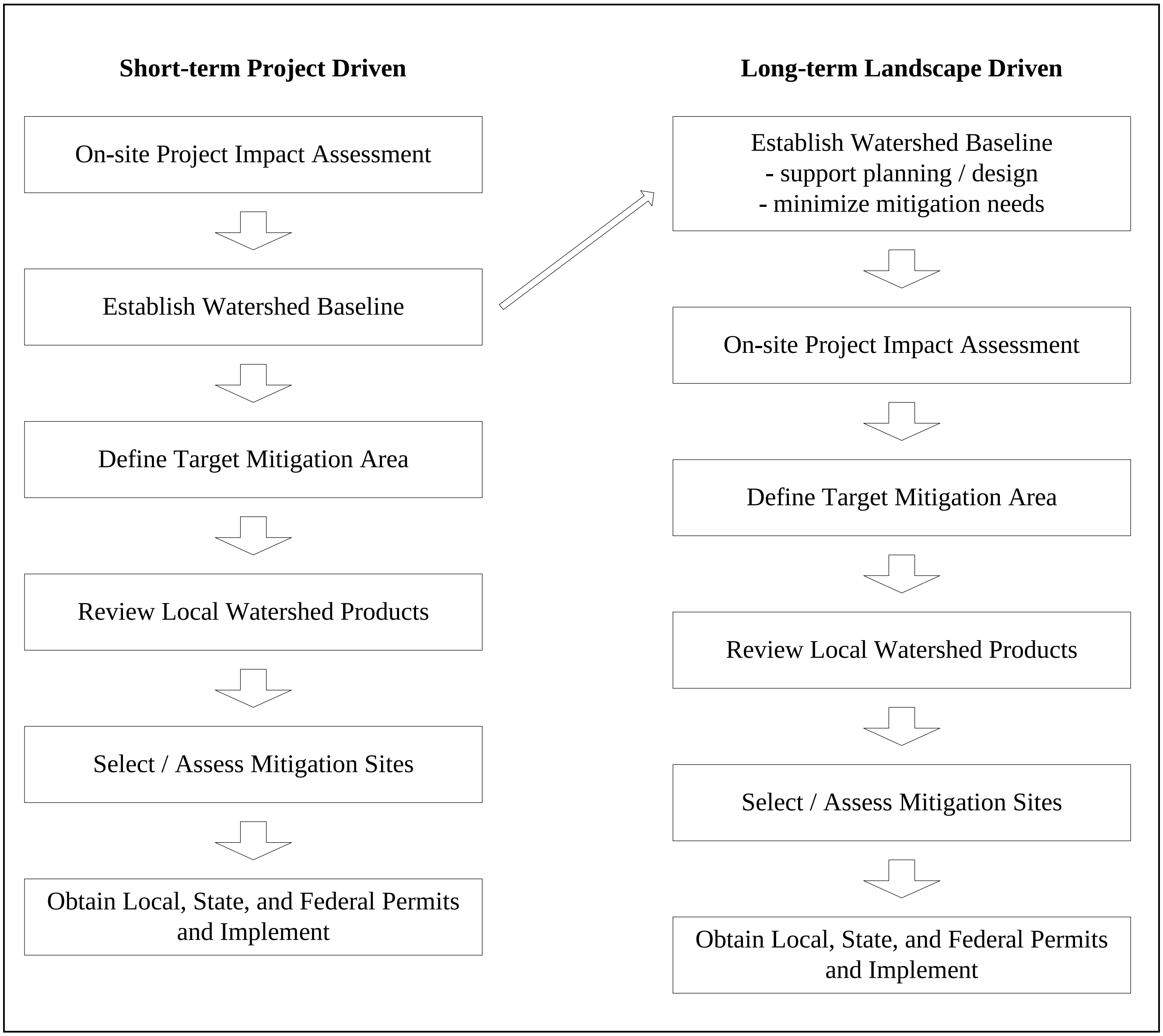

Figure 1. Comparison of Short- and Long-term Approaches to Watershed Characterization.

Watershed Characterization Products

Watershed characterization has potential to provide information needed for environmental impact assessment under NEPA and SEPA and the identification and assessment of mitigation alternatives. Watershed characterization results in the form of narrative descriptions and/or tabular and Geographical Information System (GIS) data will be provided for each assessment step for use by regional biologists in the development of regulatory documents. Further, it is the intent of the authors to provide the transportation project management team with a suite of mitigation options and supporting documentation that they can then use to select a preferred mitigation option or options that best meet their project needs.

Overview

Guiding Principles

The following guiding principles serve as the fundamental building blocks on which landscape-scale assessment methods are developed. All of the guiding principles listed below have an established policy and/or technical rationale. However, it should be noted that they are assumptions.

Because watershed characterization methods are new or in-development, safeguards need to be in place to minimize the risk of adverse environmental impacts.

Mitigation, in advance of project impacts, reduces the uncertainty and risk regulatory agencies take in permitting a mitigation site that is constructed concurrently with project impacts. Conversely, the transportation agency takes an additional risk when mitigating anticipated transportation impacts that may occur sometime in the future. Development of mitigation sites five or more years in advance of project impacts provides substantial opportunity for achieving a fully functioning mitigation site prior to project impacts.

Mitigation must first maximize opportunities to avoid and minimize transportation impacts.

Opportunities to maximize avoidance and minimization of natural resource impacts exist when environmental assessment occurs well in advance of transportation planning and design. However, the existing transportation project planning and design process does not maximize this potential. The long-term vision for watershed characterization is to begin impact assessment five to seven years before the transportation project is constructed to ensure that key environmental information is available prior to extensive planning and design work.

Do no further harm to aquatic resources and, when possible, build in incremental improvements necessary to protect, restore, and enhance the functions of the state's water bodies.

Completing watershed characterization very early in the transportation planning process is intended to maximize potential to avoid and minimize impacts of transportation projects by providing key environmental information to planners before the design process begins. Currently, mitigation planning is focused on getting necessary environmental permits. Watershed characterization seeks to identify many potential mitigation opportunities at larger landscape scales, facilitate cost-benefit analysis, and select mitigation options having the greatest potential to maximize environmental benefit.

Watersheds are a fundamental planning/management unit for developing natural resource and stormwater mitigation/compensation strategies.

Major initiatives intended to aid in the recovery of salmon stocks listed as “threatened” or “endangered” under the ESA and to restore polluted water bodies in the Pacific Northwest have embraced watershed-scale planning and implementation. Further, stormwater management efforts are now beginning to explore the applicability of watershed assessment tools. Watershed characterization efforts seek to use landscape-scale planning and analysis to maximize environmental, social, and economic benefits of dollars spent to mitigate transportation impacts.

Resource characterization work within tribal Usual and Accustomed Areas will dictate that the affected tribe(s) will be consulted and involved, to the extent of their interest, to ensure that their right to fish habitat protection is guaranteed.

Indian Tribes of the State of Washington are guaranteed the right to protection of the fish habitat within their Usual and Accustomed Areas (Orrick Decision). Transportation impacts to fish habitat and all associated mitigation actions will result in consultation with the appropriate Tribe or Tribes to ensure that no net loss of the Tribal Usual and Accustomed Area will occur. Watershed characterization five to seven years before project construction will help ensure that Tribal concerns regarding project impacts to fish habitats are identified prior to an extensive investment in project planning and design.

Good planning dictates that potential mitigation sites be assessed to determine their ability to maintain functions restored under both current and anticipated future land uses.

Natural resource impacts from transportation projects are assumed to be permanent. Yet mitigation sites are too often selected solely on their capability to restore necessary functions under current surrounding land use conditions. If impacts are assumed to be permanent, it is imperative that mitigation sites have the greatest potential to maintain restored functions over the long-term. Mitigation must occur in areas where surrounding land use will not preclude the long-term maintenance of restored functions. Understanding the relationship between past, present, and future conditions of a watershed is an important part of watershed characterization and is essential to successful, effective mitigation planning.

Financial investments in environmental mitigation must be maximized.

The cost of environmental mitigation is rapidly rising. Land availability, the cost of land that is available, and the sophisticated designs needed to mitigate project impacts in urban areas are all key factors in the mitigation cost equation. Watershed characterization seeks to reduce the cost of mitigation by: 1) mitigating within the project right-of-way only to the natural capacity of the site; 2) targeting out of right-of-way mitigation to "at risk" drainages with moderate intensity land uses, high potential for measurable environmental gains, and reduced land values; 3) completing watershed characterization five to seven years prior to project completion provides opportunities for advanced mitigation or mitigation banking; 4) reducing mitigation site maintenance costs by restoring self-maintaining ecological processes rather than replacing structure elements (such as large wood in streams, engineered detention ponds or vaults) that require consistent maintenance and have a limited operational life.

Focus on individual mitigation sites is only appropriate after there is some understanding of how those sites fit into a landscape context.

Methods are needed that place site-specific restoration actions within a watershed context (Roni et al. 2002). Informed land management decisions require high-quality information focused on key processes and linkages that create and shape ecosystems (Montgomery et al. 1995). By focusing solely at the site scale, managers are limited in their ability to understand how each mitigation site relates to the long-term maintenance of ecosystems. Without this understanding, mitigation efforts can target symptoms of ecosystem degradation rather than core problems that must be addressed to ensure that functions are maintained over the long-term (Gersib et al. 1999, Beechie and Bolton 1999). Watershed characterization seeks to better understand project impacts within a broader landscape context, target the restoration of ecological processes in drainages having the greatest potential for measurable environmental benefit, and identify many mitigation options that have potential to maximize environmental benefit while reducing cost.

Mitigation actions should focus on the restoration of ecological processes that create and maintain functions.

The restoration of ecological processes has become widely accepted as the key to restoring watershed health and improving fish habitats (Beechie and Bolton 1999, Roni et al. 2002). Characteristics of streams and rivers reflect variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbances, and the dynamic features of the riparian forest (Naiman et al. 1992). These physical attributes influence how water, sediment, large wood, nutrients, and heat are delivered and routed through a catchment area. Substantial agreement is emerging that the delivery and routing of water, sediment, large wood, nutrients/toxicants, and heat are the key ecological processes regulating the vitality of watersheds and their drainage networks in the Pacific Northwest coastal ecoregion (Naiman et al. 1992, Reid 1993, Gersib et al. 1999, Beamer et al. 1999, Roni et al. 2002). Effective restoration targets the underlying ecological processes that create and maintain the structural elements of a site rather than merely adding structures or otherwise attempt to save the worst-degraded or most visibly damaged areas (Frissell 1993, Gersib et al. 1999). Neglecting ecological processes that cause natural resource degradation can lead to physical failure of projects or increased maintenance costs (Frissell and Nawa 1992, Beechie and Bolton 1999, Roni et al. 2002). The assessment and understanding of ecological processes are essential components of watershed characterization.

A landscape-scale biological context is needed to develop the understanding necessary to focus on the recovery of systems that support native plant and animal communities rather than on the recovery of a single species.

Understanding wildlife species in a community or ecosystem context will minimize potential for mitigation projects that help one target species but harm others (Reeves et al. 1995, Beechie and Bolton 1999). Watershed characterization seeks to understand human effects on ecological processes that create and maintain the unique structure elements (habitat) that support all aquatic and terrestrial wildlife species. When recovery efforts focus on ecological processes, the focus is on the denominators common to all species, rather than on one or more specific structural elements of the habitat of a single species.

To maximize environmental benefit, the focus of recovery efforts is recovery of ecosystem elements and processes.

This condition is likely to be met only in low-development areas with relatively low to moderate levels of ecological health, because the agents of degradation are probably easier to identify and more amenable to correction (Booth et al. 2001).

Resource characterization must incorporate multiple spatial and temporal scales to better understand the magnitude and extent of human effects on natural resources and how best to mitigate those impacts.

Any analysis of watershed condition needs to assess the variability of watershed functions and characteristics over time and space (Euphrat and Warkentin 1994). Communities and landscapes form the ecological and evolutionary context for populations and species; preserving integrity at a landscape-scale is critical to species persistence (Angermeier and Schlosser 1995). Mitigation projects should focus on restoring the temporal regimes and spatial diversity of the natural habitat system by affecting the processes that determine these patterns (Frissell 1993). Watershed characterization seeks to better understand the effect of human land use on ecological processes at different spatial and temporal scales and then use this understanding to select potential mitigation sites that maximize environmental benefit.

Locally defined watershed recovery priorities will be used as an important tool in the final selection of mitigation options.

Recovery priorities can and should be based on a narrower range of locally generated biological objectives, but only to the extent that local prioritization remains subordinate to restoring ecological processes and meeting specific project mitigation needs (Beechie and Bolton 1999). Watershed characterization methods must, first and foremost, identify sites that mitigate transportation impacts within areas that have potential to maximize environmental benefit. However, within this context, recovery priorities of the local watershed planning process will serve as the recovery theme for the project, when possible, and local priority recovery projects will be advanced when they can satisfy mitigation needs and fall within targeted recovery areas.

Selection of Transportation Projects

While it is apparent that watershed characterization will benefit the transportation planning and design process, not all projects warrant this analysis tool. Until specific criteria are established, it is assumed that the following general project attributes will maximize benefits of watershed characterization:

- Project located in an urban or urbanizing area
- Project has substantial potential to effect important natural resources, or resource impacts are complex
- Project extends across a large and diverse landscape area

Substantial potential exists to use the 6-year and 20-year transportation plans to develop a screening tool that provides regional transportation offices with information on out of right-of-way mitigation needs and the complexity of environmental mitigation. This information in turn, will be used to determine the need for watershed characterization.

Establishment of Technical Team

Understanding the cumulative effects of land use impacts on ecological processes at landscape-scales requires expertise in hydrology, hydrogeology, ecology, biology, and many other scientific disciplines (Reid 1993). This dictates the formation of a technical team that works together to develop an interdisciplinary understanding of project impacts and mitigation options. To meet this need, an interdisciplinary technical team should be formed consisting of a hydrologist, hydrogeologist, ecologist, biologist, and water quality specialist. Essential technical support from a GIS analyst and GIS technician will also be required.

Local Watershed Coordination

Local watershed planning efforts are considered to be a fundamental mechanism for the landscape-scale mitigation of transportation projects. Watershed councils and planning groups function as decision support systems in local management efforts. These groups bring stakeholders together to develop plans that consider all local interests and concerns. For this reason, local planning initiatives are assumed to be most effective at understanding and addressing the needs and priorities of local residents and the natural resources on which they depend. Local watershed planning groups often acquire and compile local or regional data sets that can be of substantial value to transportation-related watershed characterization efforts.

Incorporating local watershed planning efforts at the earliest stages of environmental planning creates additional opportunities for the collection of locally developed data that are needed for watershed characterization. Finally, local watershed planning efforts often identify a suite of recovery sites and actions that have potential to satisfy transportation mitigation needs and assist local governments in achieving watershed management goals and objectives.

General Framework for Watershed Characterization

The conceptual framework for watershed characterization was developed by the primary author with oversight and review of the TPEAC Watershed Subcommittee. Development of this framework builds on Washington State Department of Ecology (Ecology) efforts at watershed characterization (Gersib et al. 1999) and those of the Skagit Watershed Council (Beamer et al. 1999). It was also influenced by many technical publications. Noteworthy publications include work by Naiman et al. (1992), National Research Council 1992, Reid (1993), Doppelt et al. (1993), Karr (1995), Montgomery (1995), Montgomery et al. (1995), Reeves et al. (1995), Frissell and Doppelt (1996), Beechie and Bolton (1999), National Research Council (1999), and Roni et al. (2002).

This approach outlines a scientific framework and set of procedures for identifying, screening, and prioritizing a suite of options to transportation project managers capable of mitigating environmental impacts. The scientific framework developed for mitigation planning has been developed within the following three assessment categories:

- Project site assessment;
- Watershed-scale characterization, and

- Identification and assessment of potential mitigation sites.

Within these three assessment categories lie the following series of generalized steps that form the scientific framework for watershed characterization.

1. Establish a recovery theme for mitigation based on local watershed priorities;

2. Define appropriate spatial scales to be used in watershed characterization;

3. Compile land use/land cover information for pre-development and current conditions and estimate the type and extent of future growth/development;

4. Develop an understanding of the ecological processes within drainages occurring in the project area, identify key drivers for those processes, and begin to understand how past and present land use has altered processes and disturbance regimes;

5. Assess landscape sensitivity to process alteration and identify areas most sensitive and most resistant to development;

6. Characterize the general condition of ecological processes within the largest acceptable landscape scale;

7. Identify landscape areas having specific levels of degradation to targeted ecological processes under current conditions;

8. Assess the probability that restored processes within target landscape areas will be maintained over the long-term using the future build-out scenario;

9. Identify potential transportation project impacts qualitatively (secondary effects) and quantitatively (primary effects) by resource, area, and function;

10. Translate functions to be mitigated at the site scale to equivalent ecological processes to be mitigated at the landscape scale;

11. Evaluate natural capacity of the project right-of-way to mitigate resource impacts;

12. When natural capacity of the project right-of-way is inadequate, work with local watershed planning groups to identify available information/data and understand local watershed priorities;

13. Identify restoration sites identified and prioritized by local watershed groups that occur within targeted landscape areas;

14. Identify other sites within targeted landscape areas having potential to restore ecological processes;

15. Assess each site's potential to meet project mitigation needs, with highest priority going to sites meeting assessment criteria and identified and prioritized for recovery by local watershed groups;

16. Determine area and functions that each potential site is capable of providing if restored and develop basis cost estimates;

17. Develop list of potential mitigation opportunities and prioritize based on local priorities and estimates of area, functions, and cost.

18. This framework employs and adapts the five-step strategy outlined by Beechie and Bolton (1999). A complete, detailed scientific framework for watershed characterization is presented in this report.

Characterization Within the Planning and Design Process

While the scientific framework for watershed characterization identifies the technical steps to be completed, it does not identify when these steps are to be done within the overall transportation project planning and design process. The Watershed Subcommittee was used as the forum for developing recommendations regarding the timing of watershed characterization within the project planning and design process.

The Watershed Subcommittee identified the following key points to be considered when developing a watershed characterization program:

- It is essential that watershed characterization methods be integrated or "institutionalized" into the existing transportation planning and design process;

- Transportation funding has traditionally been connected to individual projects. To facilitate watershed characterization 5 or more years in advance of a transportation project, new funding sources will be needed to acquire needed technical information and complete watershed characterization.

- A screening tool is needed to rapidly evaluate and identify transportation projects on the 6-year transportation plan that warrant watershed characterization.

- Within watersheds of interest to transportation, environmental staff should play a cooperative role in local watershed planning.

Methods Part I. Watershed Characterization and Cumulative Impact Assessment

The Approach

This is the first part in three sets of characterization steps. This first step seeks to characterize the effects of human land use on ecological processes (both physical and biological). The ecological processes focused on in this work include:

Physical processes:

- Delivery and routing of water
- Delivery and routing of sediment
- Delivery and routing of nutrients/toxicants/bacteria
- Delivery and routing of large wood
- Delivery and routing of heat

Biological processes:

- Aquatic integrity
- Upland habitat connectivity

The alteration of these core ecological processes (or pathways) by human land uses result in a change in physical structure or biological elements that will, in turn, result in a change in how a site functions. Many ecological processes operate over large spatial and temporal scales. To address core problems that often exist miles from site where functions are degraded, it is imperative that recovery efforts focus on reversing the effects of human land use on ecological processes. Further, focusing on the restoration of ecological processes avoids the misapplication of restoration techniques by enabling the natural array of structural elements to form and provide functions in all parts of a stream system (Roni et al. 2002). This holistic approach to natural resource recovery avoids the pitfalls of building structure elements that are single-species centric and not self-maintaining (Figure 2).

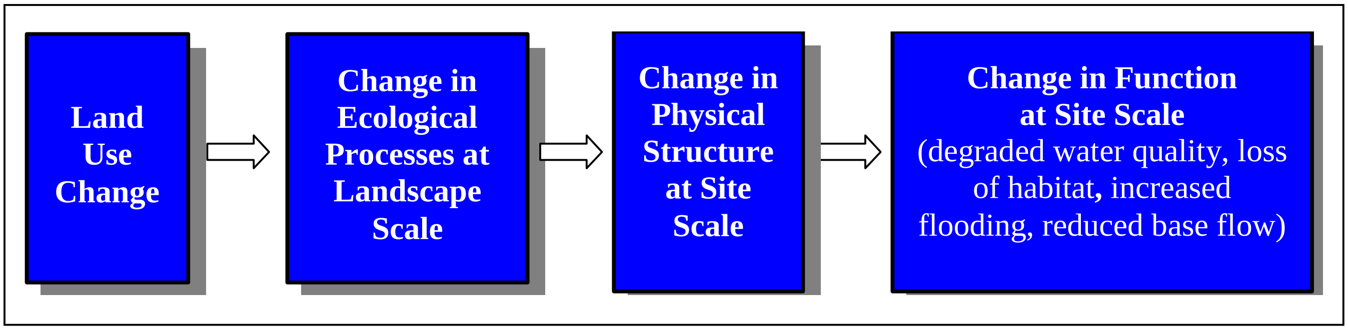

Figure 2. Generalized Steps of Degradation.

This approach seeks to better understand the relationship between land use change and the resulting change in ecological processes. This approach also seeks to understand the relationship between a change in ecological processes and the resulting change in site functions. This sequence was chosen to establish a link between degraded function and the core land use problems that may be miles from the actual project site (Figure 3). Long-term recovery will require the establishment of landscape pathways that target core problems causing degradation of ecological function.

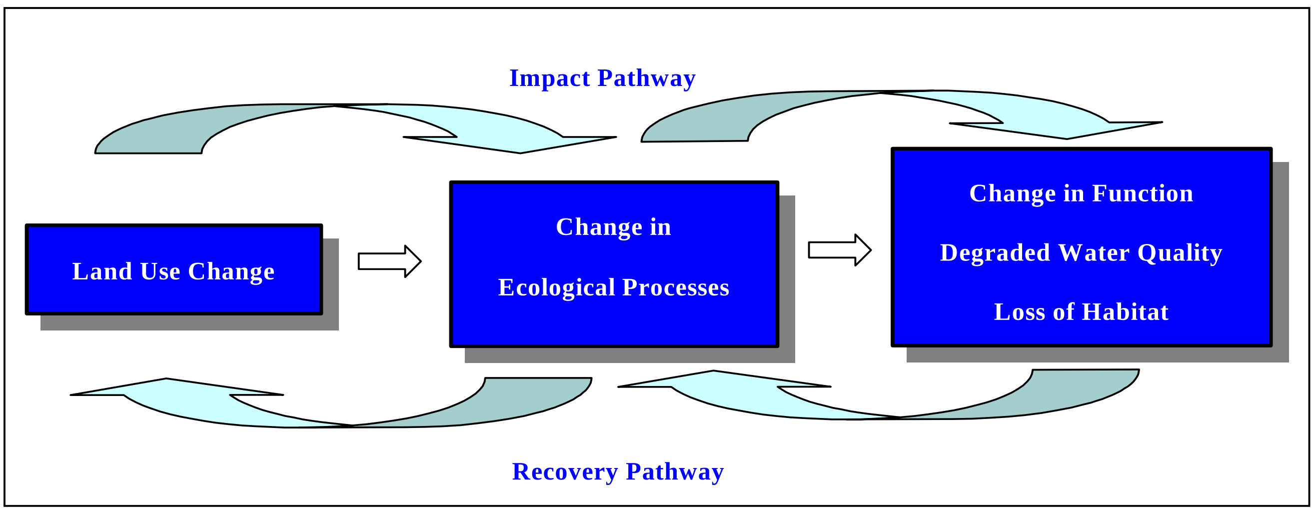

Figure 3. Long-term Recovery Pathways.

Step 1. Establish Spatial Scales of Analysis

Purpose

This step serves three distinct purposes. First, it defines the area of potential impacts of a transportation project. Second, it establishes a series of nested spatial scales within which mitigation opportunities will be identified and assessed. This step is intended to serve as a learning tool to help WSDOT and permitting agencies better understand the types of mitigation opportunities that can be expected at different spatial scales and under different land uses. Because this is a test case, more spatial scales are being used than would be when watershed characterization is in an implementation phase. While it is solely the responsibility of the permitting agencies to determine the proper scale for each regulated resource, there have been few, if any, field evaluations to assist agencies in making determinations regarding appropriate scales. Land use intensity has a strong influence on the spatial scale required to optimize social, economic, and environmental functions gained from mitigation. It is assumed that as land use intensifies, the spatial scale required to optimize mitigation site function must increase. To maximize natural resource sustainability, is assumed that mitigation should occur as close to the area being impacted as possible. Together these concepts suggest the possibility of variable spatial scale limits for mitigation based on the intensity of surrounding land use. The evaluation of test sites is needed to provide new perspectives that decision-makers can use to help understand if/when a sliding scale of spatial analysis is plausible or if one single spatial scale is more appropriate when mitigating transportation impacts.

Finally, this step will help determine if other landscape stratification tools, outside the more commonly accepted watershed boundaries, have merit when determining the area in which the mitigation of natural resource impacts can be mitigated. Omernik (1995) has developed a hierarchically based tool to stratify the landscape into more homogeneous units. Ecology (R. Gersib, personal communication) has used the fourth-level ecoregions developed by Omernik to assist in characterizing wetland resources in the Nooksack River Basin in northwestern Washington State. The evaluation of test sites will be used to help understand if landscape stratification by ecoregion has value when mitigating transportation impacts at a landscape scale.

Step 1A. Establish Drainage Areas

Definition

The study area is divided into manageable units for characterization. This unit is termed a “Drainage Analysis Unit” or DAU. DAUs are surface catchments of approximately 200 to 2000 acres that each drain to an individual stream system that the transportation project crosses.

DAUs should be consistent with the locally delineated drainage areas within the assessment area and small enough to minimize substantial variability in land use intensity. If local planning units have already sub-divided the composite sub-watershed into drainage areas that meet the criteria above, locally developed boundaries should be used. When floodplains occur in the composite sub-watershed, delineate the floodplain boundary, divide the floodplain into left bank and right bank areas, and partition the floodplain into stream reaches or other logical divisions that meet the size definition for drainage area.

Purpose

Two purposes exist for delineating drainage areas associated with a transportation project. First, the drainage area scale has potential for assessing direct impacts of the transportation project and cumulative impacts of the project and surrounding land use. This scale was established, in part, because of Ecology guidance and the need to assess and address stormwater impacts on an individual stream basis. Second, the drainage area scale is used in Part II, Step 3 as the fundamental spatial scale for characterizing the condition of larger spatial scales.

Methods

1. Acquire Digital Elevation Model (DEM) data of the sub-watershed.

2. Use the automated DEM analysis to develop drainage boundaries.

3. In areas with low topographic relief, drainage boundaries should be delineated by hand on a US Geological Survey (USGS) topographic base-map, using stereo-paired aerial photos when available. Then digitize boundaries into the project GIS database.

Data Needs

1. DEM data

2. Topographic data

Product

A GIS data layer of drainage areas within the study area.

Step 1B. Establish Study Area

Definition

The study area is the sum of all drainage areas which the transportation project crosses, less areas removed because they are not available for mitigation or are too far away to provide effective mitigation.

Purpose

The study area serves as a spatial scale that can be used to define the limits of potential mitigation sites.

Methods

The study area is established through a GIS process of displaying the drainage areas data layer and dissolving all interior polygons. Large, discrete sections of land, such as forest reserves or military bases that occur within this area may be removed. If the initial study area is extensive, areas that are very far from the transportation project may also be removed. Both of these steps will help to reduce the amount of detailed analysis that will be required in subsequent steps.

Data Needs

Drainage areas data layer.

Product

A GIS data layer of the project study area.

Step 1C. Establish Sub-watershed Areas.

Definition

Sub-watershed is the catchment area of a stream or streams comprising 20 to 50 square miles and equivalent to a Washington Department of Natural Resources (WADNR) Watershed Administrative Unit (“WAU”) or US Geological Survey 5th field Hydrologic Unit Code (“HUC”) in which the transportation project occurs.

Purpose

Establish a spatial scale for analysis of potential mitigation sites that represents a substantial tributary or group of lesser tributaries to larger catchment areas.

Methods

1. Identify and acquire available spatial data from local, state, tribal, and federal sources.

2. Use the following criteria to select which existing spatial data set to use to define the sub-watershed boundary:

    a. Scale of area meets general size definition of a sub-watershed area;

    b. Spatial data set is used by local or regional group doing watershed-scale natural resource management; and

    c. Spatial data set has sub-watershed boundary that best lends itself to the transportation project.

    Spatial scales meeting criterion a are then evaluated to identify those meeting criteria b. If more than one data set meet both criterion a and b, criterion c would be used to make the final selection.

Data Needs

Available local, state, tribal, and federal spatial data.

Product

The GIS data layer of the sub-watershed or sub-watersheds in which the transportation project occurs.

Step 1D. Establish Groundwater Aquifer Area.

Definitions

Groundwater aquifer is that portion of the regional groundwater aquifer that has potential to be affected by the transportation project.

Regional groundwater system is the regional aquifer area.

Purpose

Surface water catchments have been the standard tool when delineating spatial boundaries for watershed analysis. Groundwater flow paths generally follow surface topography, but there is growing evidence that this should not be automatically assumed. This spatial scale will be used to begin developing an understanding of similarities and differences in groundwater and surface water flow paths.

Methods

1. Identify and acquire existing data on local and regional groundwater aquifers.

2. Use best professional judgment of the interdisciplinary technical team to identify the groundwater spatial scale that has most relevance to the transportation project study area.

Data Needs

Available data on local and regional groundwater aquifers.

Products

A GIS data layer of the groundwater aquifer area.

Step 1E. Establish Watershed Area.

Definition

Watershed is defined as the drainage area of a major river system. In Washington State, the watershed scale is defined as a Water Resource Inventory Area (WRIA) as defined in Chapter 173-500 WAC.

Purpose

Define the largest potential spatial scale for identifying mitigation sites.

Methods

1. Access the WRIA data layer.
2. Locate the transportation project within one or more WRIAs.
3. Develop a watershed data layer comprising the identified WRIAs.

Data Needs

Ecology WRIA data layer.

Product

A GIS data layer of the project watershed.

Step 1F. Establish Lithotopo Units

Definition

Lithotopo Unit is that part of the sub-watershed having a common 4^{th} level ecoregion and surficial geology as the project area.

Purpose

Compared to surface water catchment-based spatial scales, lithotopo units are geology/ topography-based means of stratifying the landscape. Because of this difference, it is assumed that lithotopo units have potential to increase success in the in-kind replacement of functions needed to compensate for transportation project impacts. The Environmental Protection Agency (EPA) has completed a 4^{th} level ecoregion data layer for much of the United States. Montgomery (1999) uses the term lithotopo units to define finer-scale areas with similar topography and geology, within which similar suites of geomorphic processes influence gross habitat characteristics and dynamics. Further, unpublished data on watershed-scale wetland restoration assessment and planning in the Nooksack Basin, Washington (R. Gersib personal communication) indicate that the stratification of 4^{th} level ecoregions by surficial geology appears to substantially reduce variability in wetland size, hydrogeomorphic class, and functions provided. Lithotopo unit area was chosen as an experimental spatial scale that will be evaluated throughout watershed characterization methods development.

Methods

1. Acquire Levels III and IV ecoregions data layer from the EPA Spatial Data Library System.
2. Clip ecoregions data layer to the boundary of the study area.

3. Subdivide the study area level IV ecoregions.

4. Overlay the Level IV ecoregions and geology onto the project sub-watershed.

5. Refine the 1:250,000 Level IV ecoregion boundaries based on 1:100,000 geology units.

6. Use surficial geology units to further subdivide Level IV ecoregions.

7. Each polygon represents a lithotopo unit. Name each mapping unit and create that lithotopo data layer.

Data Needs

1. EPA 4th level ecoregion GIS data layer

2. Surficial geology

Product

A GIS data layer of the lithotopo units within the project right-of-way and the location of those same lithotopo units within the study area.

Step 2. Establish Temporal Scales of Analysis

Purpose

While project impact assessment requires only an understanding of the transportation project and the current state of the natural resources that will be impacted, cumulative impact assessment and an assessment of water quality loading rates under a build-out scenario require multiple temporal scales. Pre-development and current land use conditions are needed to assess cumulative impacts and the project's contribution to it. Current and future build-out conditions are needed to understand potential future cumulative impacts in a build-out scenario and assess the potential that candidate mitigation sites have to maintain function over time. Without an understanding of the pre-development and future build-out conditions and the associated analysis, it will be more difficult to identify and select of the mitigation site with the greatest potential to maximize environmental benefit and minimize mitigation cost.

Step 2A. Create a Pre-Development Data Layer

Purpose

A pre-development land use data layer is the reference point for assessing the current and future state of natural resources. Mitigation of adverse impacts has tended to focus on replacing natural resources based on qualitative and quantitative assessment of project effects, without a landscape context. While this has been an acceptable approach in the past, natural resource managers are beginning to recognize that long-term mitigation effectiveness is often dependent on surrounding landscape conditions (Booth et al. 2001, Roni et al. 2002). In turn, an assessment of landscape condition requires an understanding of the extent of change in ecological processes from a pre-development to present and future land use conditions.

Methods

1. Acquire available data on the pre-development land cover condition of the sub-watershed and determine adequacy.

2. When data for a pre-development land cover is not available, compile data from historical data sets.

3. Overlay the geology data layer onto the area to be assessed and use this information to provide insight into areas of potentially different vegetation communities.

4. In historically forested parts of the state, access General Land Office (GLO) data in the Washington State Library and compile land cover vegetation information for each geologic mapping unit within the area of interest. GLO vegetation data include tree/shrub species and tree/shrub diameter breast height (DBH) for each section corner, and each half- and quarter-mile section line. For small areas, all vegetation data should be compiled and entered in a spreadsheet. For larger areas, a sample of vegetation data by geologic unit can be compiled.

5. Develop a GIS data layer that displays data in colored circles at each sample data point. Color circles green for coniferous and red for deciduous. Circle size should be scaled to the DBH of each sample tree. Group DBH size into 1-12 inch, 13-24 inch, 24-36 inch, and greater than 36 inch DBH.

6. Compile available historic maps of stream systems and when available add to the pre-development land cover data layer.

7. For pre-development grassland areas, follow the same process using grassland communities.

Data Needs

Available pre-development land cover data for the sub-watershed.

Product

A narrative characterization or GIS data layer of pre-development land cover.

Step 2B. Select a Current Land Use/Land Cover Data layer

Purpose

Current land use/land cover data are used in three ways. First, this data set is used with the pre-development data layer to gain perspective on the extent of change in land cover. Second, this data layer is used to calculate key landscape attributes used to characterize the extent of alteration in ecological processes. Finally, this data layer is used to target areas within "at risk" drainages having potential to mitigate transportation impacts.

Methods

1. Contact local, state, federal, and tribal sources of land use/land cover data to determine available data options for the study area.

2. Select the most current land use/land cover data set. Preference should be given to the land use/land cover data set that is being used in local watershed planning.

3. When data are not available for portions of the study area, use the most current aerial photos or other data sources to construct a complete land use/land cover data set.

Data Needs

Current land use/land cover data.

Product

A GIS data layer of current land use/land cover.

Step 2C. Create a Future Build-Out Land Use Data layer

Purpose

Conventional methods for identifying and assessing potential mitigation sites primarily focus on assessing a site's ability to mitigate project impacts under current conditions. This approach does that, but also seeks to understand the future development pressures that will influence a site's ability to maintain environment functions. Surrounding land use influences how a site functions.

This approach is intended to help resource managers gain a better understanding of a mitigation site's potential to mitigate project impacts and maintain environmental function over the long-term. Resource impacts are assumed to be permanent. Mitigation sites must be screened to ensure they have the greatest potential to replace and maintain functions over the long-term.

Methods

1. Compile comprehensive plans from local jurisdictions in the study area. Use plans developed under the Growth Management Act where available. If possible, obtain the information as a GIS data layer.

2. Examine the definitions of the land use categories in each jurisdiction's comprehensive plan, and consolidate them into a concordance table of land use categories that apply to all jurisdictions. Assume that existing developed lands will remain unchanged, and that wetlands and steep slopes will remain undeveloped. Apply future land use codes to the remaining data. This is most easily accomplished in ARC/INFO GRID as follows:

    a. POLYGRID existing land cover data layer to create an existing land cover grid.

    b. POLYGRID wetlands data layer to create a wetlands grid.

    c. POLYGRID consolidated future land use data layer to create a future land use grid.

    d. Using GRID algebra, subtract existing land use from future land use to create a grid of undeveloped lands.

    e. Subtract wetlands and steep slopes from undeveloped lands to create a grid of developable lands.

    f. GRIDPOLY the developable lands grid to facilitate further analysis.

Data Needs

1. Current land cover.

2. GIS data layers for wetlands and steep slopes.

3. GIS data layers for all local comprehensive plans.

Product

A GIS data layer of future build-out land use.

Step 2D. Estimate Total Impervious Area for Existing and Future Build-Out Conditions

Purpose

Total Impervious Area (TIA) is used in watershed characterization to describe the degree of hydrologic alteration within drainage basins. It is defined as the percentage of land within an area that is impervious to water, and includes rooftops, paved surfaces, and compacted earth. TIA is derived from land use/land cover data, and is a key indicator of ecological condition.

Methods

1. Estimate TIA within each drainage basin for existing conditions. For detailed watershed modeling, TIA is often estimated through analysis of aerial photographs and field inspection. Watershed characterization is performed at a much larger scale, and TIA must be estimated from more readily available data. Landsat images have been analyzed in many regions to identify the dominant land cover within each 30-meter Landsat pixel. TIA values for land cover categories can then be assigned based on relationships described by Booth and Jackson (1997), Azous and Horner (1997), and Booth et al. (2001), a shown in Table 1.

Table 1. Total Impervious Area values for land cover categories.

Land Cover Class	Percent TIA	Source
Forested (deciduous, coniferous, mixed)	3	Booth et al. (2001)
Grass, pasture, bare earth, recent clear cuts, scrub/shrub, herbaceous	5	Booth et al. (2001)
Mixed urban/low density (assumed to be equivalent to suburban)	35	Booth and Jackson (1997)
Urban/high density (assumed to include commercial, industrial, office space, high density residential)	75	Midpoint of range from Azous and Horner (1997)

   Although open water is often treated as impervious in hydrologic modeling, we assign it a TIA value of 0 to reflect our use of TIA as a surrogate for developed area.

2. Estimate TIA for future build-out land use, using products of Part I, Step 2C. TIA can then be estimated using literature-derived values for common land use classes, as shown in Table 2.

Table 2. Total Impervious Area estimates for common land use classes.

Land Use	Percent TIA	Source
Agricultural	5	Azous and Horner (1997)
Commercial, light industrial, downtown	75	Midpoint of range from Azous and Horner (1997)
Forestry, forested open space	3	Booth et al. (2001)
Industrial	80	Azous and Horner (1997)
Mining	80	Azous and Horner (1997) value for industrial
Schools, parks, golf courses, non-forested open space	5	Booth et al. (2001) value for grasses and shrubs
Residential High (>10 dwelling unit/acre)	60	Booth and Jackson (1997)
Residential Medium (1 to 10 dwelling units /acre)	35	Booth and Jackson (1997)
Residential Low (<1 dwelling unit /acre)	10	Booth and Jackson (1997)

Data Needs

1. Existing land use/land cover from Part I, Step 2B.
2. Future land use/land cover from Part I, Step 2C.

Products

1. TIA within each drainage basin for existing conditions
2. TIA within each drainage basin for future build-out conditions

Step 3. Characterize Resource Condition and Process Drivers in Study Area

Purpose

This step develops an understanding of the natural resources within the study area and the ecological process drivers that create and maintain them. This understanding is developed through a collaborative effort of the interdisciplinary technical team and efforts to reveal how natural systems function within the study area.

Questions to be Answered

1. What are the general surface water-groundwater relationships?
2. How does geology and land use effect surface and groundwater movement?
3. Where location, extent, and condition of aquatic and terrestrial resources exist within the study area?
4. What are the baseline conditions of the ecological processes that support habitat for ESA listed species?

Step 3A. Characterize Precipitation, Runoff, Stream Flow, Groundwater Movement, and Water Quality

Purpose

The movement of water through the landscape is governed by interactions between precipitation, land cover, soils, and geology. A key step in watershed characterization is to understand how these factors influence the routing and delivery of water, sediment, and pollutants. This provides the foundation for characterizing the condition of other ecological processes within the study area.

Methods

1. Characterize seasonal precipitation and evapotranspiration in the study area. WSDOT's MGSFlood model has hourly precipitation and evapotranspiration data for most of Western Washington.
2. Review geology maps and regional geologic studies to identify major hydrogeologic units in the study area. WADNR provides GIS coverages of surficial geology for most of the state. Groundwater resources in many areas are documented in Water Supply Bulletins published in the 1960s by the former Washington State Division of Water Resources. The U.S. Geological Survey and Ecology have updated some of these groundwater resource studies.
3. Review regional hydrogeology studies to characterize groundwater recharge, subsurface flow patterns, and groundwater/surface water interactions. Identify important groundwa-

ter recharge areas and locations where groundwater is feeding streams and wetlands. Vaccaro et al. (1998) provide a general framework for analyzing groundwater flow and recharge in the Puget Sound region.

4. Identify subsurface drinking water supplies in the study area, including sole source aquifers, critical aquifer recharge areas, and aquifer protection zones designated by local, state, and federal agencies. Identify any special groundwater protection requirements that regulate infiltration of stormwater.

5. Identify and delineate drainage basins within the study area. Drainage patterns in urban areas have been highly altered, and topographic drainage boundaries may have to be adjusted using information from urban storm drainage maps and basin planning maps.

6. Review soil surveys to characterize how soils influence runoff, infiltration, and groundwater recharge. Overlay soil maps onto drainage basin maps to identify the distribution of United States Department of Agriculture (USDA) Hydrologic Soil groups within each basin. Dinicola (2001) provides a conceptual model of runoff production from glacial till and outwash soils in Western Washington.

7. Analyze land use/land cover data to identify the distribution of urban, rural, and forested land in the study area for pre-developed, existing, and future build-out conditions (see Part I, Step 2). Analyze the distribution of impervious areas within each drainage basin.

8. Review storm drainage information and interview local stormwater managers to identify how drainage patterns have been altered by development. Identify the locations of major stormwater conveyance, storage and treatment facilities. Identify planned or proposed regional stormwater treatment facilities.

9. Review basin plans, stream gage data, drainage studies, and watershed models to characterize surface runoff and streamflow in each drainage basin. Characterize the distribution of runoff production and the timing of flood hydrographs. Identify important storage features such as wetlands and floodplain areas.

10. Estimate mean runoff and peak flow statistics at key locations in each drainage basin, including locations where streams intersect the project area. Continuous watershed models such as Hydrologic Simulation Program – Fortran (HSPF) provide the most detailed and comprehensive information, and may be available from existing watershed studies and basin planning efforts. For small basins (less than 320 acres), peak flows can be estimated using WSDOT’s MGSFlood model. Peak flow statistics in rural and forested basins can be estimated using USGS regression equations.

11. Characterize the effects of land use change on groundwater recharge and streamflow. Estimate groundwater recharge and peak flow rates under pre-developed, existing, and future build-out conditions.

12. Review and summarize existing water quality data for water bodies within the study area. Identify known water quality problems, including violations of state water quality standards. Identify relatively clean water bodies that may trigger anti-degradation require-

ments. Water quality data are commonly available from Ecology's 303(d) list and Environmental Information Management system, Total Maximum Daily Load (TMDL) studies, monitoring efforts by local agencies, and water quality studies used in basin planning. The U.S. Geological Survey Puget Sound Basin program collects data for specialized water quality studies (http://wa.water.usgs.gov/ps.nawqa.html).

13. Review basin plans and studies to identify major sources of pollutants within each drainage basin. Pollutant loading studies and modeling efforts can provide information on the distribution and magnitude of pollutant loads. Where these are unavailable, analysis of land use/land cover can be used to identify potential pollutant sources.

Data Needs

1. Hourly precipitation and evapotranspiration
2. Surficial geology data layer
2. Groundwater resource studies
3. Sole source aquifer, critical aquifer recharge area, and aquifer protection zone data layers
4. Soil survey data layer
5. Pre-developed, existing, and future land use/land cover data layers
6. Topographic data layers and urban drainage maps
7. Streamflow data
8. Existing basin plans, drainage studies, watershed modeling studies
9. Water quality data for water bodies in the study area

Products

1. Description of groundwater flow paths and interactions with surface water resources
2. Maps and description of subsurface drinking water supplies and groundwater recharge areas
3. Rainfall-runoff and groundwater recharge relationships for the study area
4. Description of the distribution of streamflow and runoff production in each basin.
5. Peak flow estimates for each stream that intersects the project area.
6. Locations of major stormwater storage and treatment facilities.
7. Description of how land use has altered hydrologic processes in each drainage basin.

8. Summary of water quality data in each drainage basin

9. Major pollutant sources and pollutant loading estimates

Step 3B. Determine Location, Extent, and Condition of Wetland Resources.

Purpose

Identifying the location, extent, and condition of wetlands provides valuable insight into a landscape's capacity to store surface water, sediment, and nutrients/toxicants/bacteria. This information is used to help characterize the condition of ecological processes within DAUs in the study area. The location and extent of existing, degraded, and destroyed wetlands serve as the pool of potential mitigation sites for project impacts to wetlands.

NOTE: A clear distinction must be made between a wetland inventory and an inventory of potential wetland restoration sites. Wetland inventories attempt to identify the location and extent of existing wetland resources. An inventory of potential wetland restoration sites identifies the location, extent and condition of existing wetland areas and additional historical wetlands, now upland due to human alteration, that can be reestablished through restoration actions.

A clear distinction must be made between a wetland inventory and an inventory of potential wetland restoration sites.

Methods

1. Identify and compile available data sets of the location, extent, and condition of historic and existing wetlands within the study area.

2. Evaluate effectiveness of the data at identifying potential wetland restoration sites. When existing data are adequate to use for characterizing ecological processes and identifying potential wetland mitigation sites, no additional data assessment is required. When existing data are inadequate, continue to method number 3.

3. When existing wetland data do not meet needs, use available data sets and aerial photo interpretation to develop a list of potential wetland restoration sites.

4. Existing polygons from available wetland inventories should be used to establish the location and extent of all known wetlands. All available wetland inventories are overlaid in a priority order based on assumed accuracy using ArcMap. When wetlands are identified on more than one wetland inventory, the polygon of the site in the inventory with the highest assumed accuracy is used to identify the location and extent of the potential wetland. Within Washington State, potential data sets include National Wetland Inventory, WADNR hydrography coverage (codes 111 and 421), Washington State Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) data, and local wetland inventories. Create an ArcMap data layer of existing wetlands. This data layer will function as the starting point for a potential wetland restoration data set. Wetland attributes within each wetland inventory should be evaluated for applicability to this work. Relevant attributes from each wetland data set should be imported into the new data layer table to support photo interpretation.

5. Acquire soils data and identify wetland hydric soils within the study area (hydric soils with no upland soil inclusions and hydric soils with upland soil inclusions). Clip hydric soils to the study area boundary and establish a hydric soils data layer. This data layer provides an indication of the predevelopment location and extent of wetlands in the study area.

6. To the existing wetland data layer table, add new attribute fields to the data table to allow the photo interpreter to record additional data compiled during photo interpretation. Suggested attributes to be photo interpreted and recorded in the data table include:

   - **Potwet -** This attribute represents the photo interpreter's opinion of the site's potential to be either an existing wetland or a historical wetland area that has restoration potential. This attribute is used to distinguish between wetland and potential wetland areas and upland and historic wetland areas having no restoration potential.

     Y - site is an existing wetland or has restoration potential

     N - site is not and existing wetland and has no restoration potential due to site or surrounding human land use/alteration.

   - **Rest_Pot –** This attribute represents the photo interpreter's opinion of a wetland or upland site's need and ability to be restored to a natural wetland condition. This attribute is used to distinguish between potential wetland sites that have potential to used as a mitigation site and wetlands that have minimal mitigation site potential.

     0 – no/minimal potential for restoration; this can include both high quality wetlands and degraded or destroyed wetlands with substantial development that precludes reasonable options to restore the wetland

     1 – wetland has some level of restoration potential based on signatures from aerial photos indicating some level of hydrologic and/or vegetative alteration

     2 – In the photo interpreter's opinion, the wetland site has adequate restoration potential to serve as a viable mitigation option

   - **Mit_pot –** This attribute represents the photo interpreter's opinion of a wetland site's potential to serve as mitigation for the Department of Transportation. This attribute is based soling on the signatures observed during photo interpretation. Considerations used to determine mitigation potential include the size of the potential restoration site, the extent of hydrologic and vegetative alteration, indications of many separate landowners, and major infrastructure development, such as high power transmission lines or major water conveyances.

     0 – site may have restoration potential but limited potential to serve as a natural resource mitigation site do to one or more site attributes observed during photo interpretation

     1 – site has restoration potential and potential for serving as a transportation project mitigation site

- **Wclass –** This attribute represents the photo interpreter's opinion of the hydrogeomorphic wetland classification (Table 3) under existing site conditions. This attribute, paired with Pclass, can be used to describe the level of hydrologic alteration and gain understanding into potential functions that the wetland can provide under existing (Wclass) and restored (Pclass) conditions.

Table 3. Hydrogeomorphic wetland types used to classify wetlands

Hydrogeomorphic Code	Hydrogeomorphic Type	General Description
RI	Riverine Impounding	Topographic depressions on a valley bottom
RF	Riverine Flow-through	Wetland systems associated with rivers and streams where water tends to flow through rather than pond
DC	Depressional Closed	Topographic depressions outside of valley bottoms having no surface water connection to a stream
DF	Depressional Flow-through	Topographic depressions outside of valley bottoms having a surface water connection to a stream
LF	Lacustrine Fringe	Wetlands occurring at the margins of deepwater lakes
LC	Lacustrine Open Water Lake	A lake system >20 acres in area and >2 meters deep
SL	Slope Wetland	Wetlands occurring on a slope where water tends to sheet flow through
UN	Unknown	Unable to determine hydrogeomorphic type from photos
NW	Non-wetland	Site is upland area

- **Pclass -** This attribute represents the photo interpreter's opinion of the potential hydrogeomorphic wetland classification of the site once restored. Hydrogeomorphic codes used to determine Wclass, above, were also used in determining Pclass. This attribute, paired with Pclass, can be used to describe the level of hydrologic alteration and gain understanding into potential functions that the wetland can provide under existing (Wclass) and restored (Pclass) conditions.

- **Hydro_alt -** This attribute represents the photo interpreter's opinion of the extent of human induced hydrologic alteration for the site based on photo interpretation and available locally developed information.

  0 – no/minimal hydrologic alteration

  1 – some hydrologic alteration evident but portions of the site appear to be providing reasonable levels of wetland functions

2 – extensive hydrologic alteration is evident from surface drains, sub-surface tile, filling or is presumed to exist due to current human land uses

- **Vg_alt** - This attribute represents the photo interpreter's opinion of the extent of human induced vegetative alteration for the site based on photo interpretation and available locally developed information.

  0 – no/minimal vegetative alteration

  1 – some vegetative alteration/clearing is evident from aerial photos

  2 – extensive vegetative alteration/clearing is evident from aerial photos

- **SLU** - This attribute represents the photo interpreter's evaluation of the general type of land use that surrounds the potential wetland site. Suggested land use codes are presented in Table 4.

Table 4. Suggested land use types recorded during wetland photo interpretation.

Land Use Code	Land Use Type
res	Residential
par	Park/Open Space
for	Forest
com	Commercial/Business
ind	Industrial
agr	Agriculture

- **Prsrv -** This attribute identifies high quality, high value existing wetlands that, in the photo interpreter's opinion, warrant consideration for preservation status, based on photo interpretation. Sites identified in this attribute are either high quality sites located in a forested area with minimal risk of degradation from human development or high quality sites that have some human alteration but appear to be of such high value, even if degraded, that they warrant preservation and restoration status.

  1 – site warrants consideration as a preservation site

  Notes – this attribute field is provided to allow the photo interpreter to add observations of the site not captured in the other attributes.

7. Overlay the existing wetland and hydric soil data layers onto orthophotos as a base map. The orthophoto will facilitate rapid site orientation between your computer screen displaying ArcMap and aerial photos on a flat work surface. The existing wetland and hydric soils data layers provide logical areas that identify the most probable location of current and historic

wetlands. The existing wetland data layer is then renamed and used as a starting point when identifying potential wetland restoration sites.

8. Each section of land within the study area is photo interpreted using the most current high quality stereo-paired aerial photos. We recommend a wetland biologist with experience photo interpreting wetlands and a standard stereoscope with 1:12,000 color or black and white stereo-paired aerial photos.

9. Use aerial photo transects to systematically photo interpret each section of land within the study area. Using ArcMap and the potential wetland restoration and hydric soil polygons as a starting point, compare the location and extent of wetland and hydric soil polygons

10. When the photo interpreter estimates that the location and extent of the potential wetland restoration site is substantially different (greater than 25 percent error) than that of the existing wetland polygon, the polygon is modified in ArcMap to more accurately reflect location and extent of the potential wetland restoration site, as represented on aerial photos.

11. Once all polygons within a section are evaluated and data collected and recorded in the data table, the photo interpreter should scan other parts of the section to identify wetland signatures that don't coincide with a wetland or hydric soil polygon. When additional wetland signatures are identified, a new polygon is added to the potential wetland restoration data layer and recorded in a GIS log book.

12. Use data associated with existing wetland inventories and local and regional reports when available to support determinations made during photo interpretation.

13. Add new wetland sites and data developed during field work to identify and assess wetlands within the transportation project area. Suggested attributes to be added to the potential wetland restoration site dataset relating uniquely to wetland sites within or adjacent to the project area include:

    - **Site_avoid** – This attribute represents the wetland scientist's opinion using best professional judgment of the site-specific resource value of the wetland. A value of High, Medium or Low is then assigned to the wetland for the purpose of avoidance and minimization.

      H - High Avoidance; wetland is an Ecology Category I or Category II (Ecology, 1993) and warrants the highest consideration for avoidance and minimization.

      M – Moderate Avoidance; wetland is an Ecology Category III or IV (Ecology, 1993) and warrants medium consideration for avoidance and minimization.

      L – Low Avoidance; wetland is an Ecology Category III or IV (Ecology, 1993) and warrants low consideration for avoidance and minimization.

    - **Land_avoid** – This attribute represents the wetland scientist's opinion using best professional judgment of the landscape-scale resource value of the wetland in relation to the landscape and other natural resources surrounding it. A value of High, Medium or Low is then assigned to the wetland for the purpose of avoidance and minimization.

H – High Avoidance; wetland warrants the highest consideration for avoidance and minimization based on its relationship to the natural resources around it.

M – Moderate Avoidance; wetland warrants medium consideration for avoidance and minimization based on its relationship to the natural resources around it.

L – Low Avoidance; wetland warrants low consideration for avoidance and minimization based on its relationship to the natural resources around it

- **Fin_avoid –** This attribute represents the wetland scientist's opinion using best professional judgment of the overall resource value of the wetland based on averaging the site-scale and landscape-scale avoidance and minimization rank. A value of High, Medium or Low is then assigned to the wetland for the purpose of avoidance and minimization.

  H – High Overall Avoidance; wetland warrants the highest consideration for avoidance and minimization based on averaging its site-scale and landscape-scale ranks.

  M – Moderate Overall Avoidance; The wetland warrants medium consideration for avoidance and minimization based on averaging its site-scale and landscape-scale ranks.

  L - Low – Low Overall Avoidance; wetland warrants low consideration for avoidance and minimization based on averaging its site-scale and landscape-scale ranks.

- **Ecol_cat –** This attribute represents the wetland scientist's opinion using the Washington State Wetlands Rating System (Ecology, 1993) and best professional judgment to categorize each wetland. A value of High, Medium or Low is then assigned to the wetland for the purpose of avoidance and minimization.

  H – High Value; wetland is an Ecology Category I or Category II (Ecology, 1993) and is a high quality or rare wetland and warrants the highest consideration for avoidance and minimization.

  M – Moderate Value; wetland is an Ecology Category III or IV (Ecology, 1993) and provides functions and values not provided in a Category I or II wetland. These wetlands warrant medium consideration for avoidance and minimization.

  L Low Value; wetland is an Ecology Category III or IV (Ecology, 1993) and may be small or isolated wetlands, with Category IV having the least diverse vegetation. These wetlands warrant low consideration for avoidance and minimization.

14. During potential mitigation site prioritization, additional attributes will need to be developed. The following attributes are used to prioritize potential wetland mitigation sites:

- **Rare_types –** This attribute identifies wetland fens and bogs considered to be rare, unique, and/or irreplaceable. Potential fens and bogs are identified using the soils data layer. We assume that potential wetland sites having hydric soils with greater than 25 percent organic matter have the greatest potential of identifying peat bogs or fens.

  0 – potential wetland sites having 33 percent or less of the polygon area in a hydric soil series having greater than 25 percent organic matter

  1 – potential wetland sites having greater than 33 percent of the polygon area in a hydric soil series having greater than 25 percent organic matter

- **Rechrg_pot –** This attribute identifies wetland sites having the greatest potential to recharge groundwater aquifers. Hydrologic code attributes within the soils data layer are used to identify soil types having moderate to high percolation.

  0 – potential wetland sites with 50 percent or less of the polygon intersecting soil mapping units with a Hydrologic Code of A or B

  1 – potential sites with greater than 50 percent of the wetland polygon intersecting soil mapping units with a Hydrologic Code of A or B

- **Sw_connect –** This attribute identifies potential wetland sites having a surface water connection as defined by wetland hydrogeomorphic classification. For this attribute, surface water connection is defined as surface water movement from the wetland to a stream or lake for all or part of the year.

  0 – potential wetland sites with a potential wetland classification (Pclass) of Depressional Closed (DC)

  1- wetland sites with a potential wetland classification (Pclass) of Depressional Flow-through (DF), Riverine Flow-through (RF), Riverine Impounded (RI), Lacustrine Fringe (LF), Lacustrine Open Water Lake (LC), or Slope (SL) wetlands.

- **Sw_flood –** This attribute identifies wetland sites having a direct connection to a perennial stream or lake. This attribute is assessed by identifying the intersection of a wetland site and a stream or lake identified on the 1:24,000 hydrography data layer.

  0 – no direct intersection exists between the wetland site and a stream or lake

  1 – a direct intersection exists between the wetland site and a stream or lake

- **Fish_acces –** This attribute identifies wetland sites having a direct connection to a perennial stream or lake and one or more species of fish have potential to access the wetland.

  0 – no direct intersection exists between the wetland site and a stream or lake or a direct intersection exists but fish do not have access to that portion of the stream or lake

1 – a direct intersection exists between the wetland site and a fish bearing stream or lake

- **Adjpub** – This attribute identifies wetland sites located on or adjacent to public lands, including schools and parks. Using the best available public ownership data, a determination of adjacency was made.

  0 – the potential wetland site does not occur on or adjacent to publicly-owned land

  1 – the potential wetland site occurs on or adjacent to publicly-owned land

- **Local_prio** – This attribute identifies potential wetland restoration sites that have also been identified as being a priority restoration project in one or more locally developed natural resource plans. Available watershed plans and recovery projects were compared with the potential wetland restoration site dataset for matches.

  0 – the potential wetland site does not occur on a local watershed plan or is not prioritized in some manner for restoration

  1 – the potential wetland sites does occur on a local watershed plan or is on a prioritized wetland restoration list

Data Needs

1. All available wetland coverages and data sets that have wetland information in them
2. Soil survey data
3. Digital orthophotos
4. 1:12,000 color or black and white stereo paired aerial photos of the study area
5. 1:24,000 hydrography
6. Fish access data
7. Public landownership data
8. Local natural resource planning documents

Products

1. A GIS data file of potential wetland restoration sites within the study area with data needed to identify, assess, and prioritize potential mitigation sites.
2. Photo interpreted data for each potential wetland restoration site that can be used to assess the extent of wetland alteration at both the site- and landscape-scales.

Step 3C. Determine Location, Extent, and Condition of Floodplain Resources.

Purpose

Identifying the location, extent, and condition of floodplain resources provides valuable insight into a landscape's capacity to store surface water, sediment, large wood, and nutrients, toxicants, and bacteria. The proportion of functioning versus non-functioning floodplains provides additional insight into potential mitigation sites for project impacts to floodplains.

Methods

1. Identify the location and extent of riparian and floodplain areas using available coverages and data.

2. Evaluate historic (Holocene) floodplain conditions. Holocene floodplain is delineated using topographic data combined with GIS coverage of alluvial soil deposits.

3. Establish condition of current floodplains within the assessment area. Using the Federal Emergency Management Agency (FEMA) floodplain coverage and orthophotos, identify the proportion of floodplain that is decoupled from the stream (area behind dikes or levees), confined (channel locked in place by dredging, rip-rap etc), and free-flowing (channel is free to migrate across floodplain).

4. Evaluate floodplain restoration potential using the following methodology focused on the potential for storage restoration, stemming from analysis of floodplain decoupling. Floodplain storage areas become decoupled due to development activities that involve the construction of dikes, revetments, and filled terraces and dredging of the river channel. In order to identify these landscape changes LiDAR (Light Detecting And Ranging) data is assembled for the drainage. From those data, produce two GIS coverages. The first is a shaded relief topographic layer, which allows for rapid and accurate identification of changes in elevation, especially involving linear features (such as dikes, roads, etc.). The second GIS coverage is a 2-foot contour topographic coverage used to quantify the extent of vertical relief for the decoupling features being analyzed. Lay these coverages over the orthophoto coverage to generate a base map for geospatial analysis of floodplain decoupling. Additional coverages for FEMA floodplains, wetlands, riparian zones (generated as part of the watershed characterization for this project (see Part I, Step 3D) are used to help identify coupled and decoupled floodplain features.

5. Each decoupled feature is then tied to the adjacent topographic features and/or the valley wall floodplain margin. From this a storage polygon is developed for each feature, depicting the spatial extent of the lost storage areas.

6. Each decoupled polygon is then analyzed for potential for restoration. To accomplish this several additional field attributes are identified and evaluated. These include land use, channel migration potential, development surrounding the site, and soils data.

7. Orthophotos are used to identify land uses for decoupled floodplain polygons. Each polygon is sorted into categories including residential, industrial/commercial, agriculture and

open space. Because of the expense involved in acquiring developed land and removing the structures, only lands in agriculture and open space are identified as having restoration potential.

8. The polygons are then evaluated to determine the extent of surrounding development (to ascertain the relative fragmentation of polygons with floodplain restoration potential). Those polygons that have less development surrounding them are deemed to have higher potential restoration value. This determines the relative level of fragmentation for each polygon and its potential to reconnect adjacent undeveloped floodplain polygons.

9. Analysis of the floodplain reveals some polygons that had been removed from the jurisdictional floodplain, probably through Letters of Map Revision ("LOMR"), etc., that are adjacent to floodplain polygons with restoration potential. Those that share attributes with the adjacent floodplain polygons are identified and categorized as non-FEMA floodplain polygons in proximity to potential restoration sites. Land use for these is examined and those that were undeveloped were deemed to have restoration potential, however they were categorized as "non-jurisdictional" polygons.

10. Next, the polygons are evaluated to determine the potential for restoration of channel migration or channel complexity. This is done by identifying remaining vestiges of channel geomorphology, most notably mender bends and confluences. Polygons adjacent to these remainder geomorphic features receive a higher value in terms of restoration potential. This is done to identify the most likely locations for restoration activities to be augmented by remaining aspects of riverine geomorphic processes.

11. The coverage showing type A and B soils is then applied to each decoupled floodplain polygon to determine the potential for restoring riparian, wetland, aquifer recharge and nutrient exchange functions for the polygon, based on the extent to which the coverages overlap. Generally a low potential site would have an overlap of less than 25 percent of the polygon. 25 – 50 percent overlap would indicate a moderate potential, and over 50 percent overlap would indicate a high restoration potential for the function being analyzed.

Data Needs

1. Current orthophoto GIS coverage
2. LiDAR or other accurate topographic data
3. GIS riparian coverage
4. GIS wetland coverage
5. GIS type A and B soils coverage
6. GIS coverage of dikes, levees, and riprap
7. GIS FEMA floodplain coverage

8. Hydrography

9. Background information on flood control activities most notably channel dredging, levee construction and flow control structures

10. Current land use/land cover

Products

Information on the floodplain systems.

Map and data tables indicating potential floodplain restoration sites.

Step 3D. Determine Location, Extent, and Condition of Riparian Resources.

Purpose

Identifying the extent, location, and condition of riparian resources provides valuable insight into a landscape's capacity to store and transport surface water, sediment, large wood, nutrients, toxicants, and bacteria (Hyatt et al. 2004, Morley and Karr 2002, Sweeney et al. 2004). This information is used to help characterize the condition of ecological processes, or aquatic integrity, within DAUs and stream catchments in the study area. The location and extent of existing deforested riparian areas also serves as a pool of potential mitigation sites for project impacts to riparian areas.

Methods

Clip the hydrography layer to the study area boundary.

Identify the extent of riparian areas using available GIS data layers. Apply a 33-meter and a 67-meter buffer to a 1:24,000 scale hydrography layer within the study area, creating a riparian buffer layer around all rivers and streams. The buffer is based on established minimum shade requirements and site potential tree height for large woody debris recruitment, respectively.

Using available riparian coverage, current land cover and digital orthophotos, create polygons around all non-forested areas within the riparian buffer. To avoid slivers and gaps in the data, snap the polygons to the buffer edge if they are adjacent.

Add attributes to this new layer of non-forested riparian areas according to existing land cover data. If land cover data is insufficient or does not exist, use digital orthophotos or stereo-pairs to photo interpret current land use. Suggestions for useful attributes include:

- Potrip – This attribute represents the photo interpreter's opinion of the site's potential to be used as a riparian mitigation site. Y – site has mitigation potential. N – site has no mitigation potential due to site or surrounding human land use.

- Landuse – This attribute represents the photo interpreter's opinion of the site's current land use. Suggested land use codes are:

Res - Residential

Com - Commercial

Ind - Industrial

Open - Parks, agriculture, open space

- Add_forest – This attribute is a measure of the polygon's proximity to forest patches, whether the polygon would add forest to the existing forest if it were chosen as a mitigation site and restored. Y or N.

- Mend_forest – This attribute is a measure of the polygon's ability to link two disjunct forest patches, if it was chosen for riparian restoration. Y or N.

- CTS – This attribute represents the range of forest cover within the polygon, how much of the area is Cleared To Stream on a scale of 1 to 3, based on the 33-meter and 67-meter buffer distance from the stream. 1 corresponds to partial clearing, 2 some trees, 3 no trees.

- Notes – This attribute provides more detail on a polygon's site information beyond what was given in the other attributes.

After the entire study area has been evaluated for non-forested riparian areas, merge the DAU and Stream Catchment boundary layers with the non-forested riparian area layer. There should now be an attribute for each polygon stating its DAU or Stream Catchment designation.

The remaining area in the riparian buffer is the forested area per DAU or Stream Catchment. Create a new layer of forested polygons within the riparian buffer.

Add the following attributes to each layer, calculating the area of each polygon.

- Area – square feet of each polygon

- Acres – acreage of each polygon

The forested and non-forested layers tables can now be exported to a spreadsheet and the data compiled for the study area, the individual stream catchments, and the individual DAUs to determine the condition of the riparian area.

Select only the non-forested polygons with mitigation potential and create a new layer. Additional attributes to help with characterization of the potential riparian mitigation sites may be included. Suggestions for useful attributes include:

- CDsoils – Overlay the soils layer and assess how much of the potential mitigation area per polygon contains C or D soil types. If a large percentage of the polygon contains C or D soils, the site will provide more benefit from mitigation than a site with A or B soils.

Greater than 50 percent C or D soils produces a value of 1, less than 50 percent has a value of 0.

- Adjpub – This attribute shows an indication of a polygon's adjacency to publicly owned lands, which can have educational or social benefits . Overlay available property ownership layers and compare the polygon's location with publicly owned lands. Public ownership within one road's width of the potential mitigation site gives a value of 1, none: 0.

- Local_prio – This attribute gives special consideration to polygons that are within areas designated by local jurisdictions as priority sites for restoration. Local priority site equals 1, none: 0.

Potential riparian mitigation polygons that intersect potential wetland or floodplain areas should be clipped to the border of the wetland or floodplain and their area and acreage recalculated.

A copy of the layer should be made and the potential riparian mitigation polygons less than three acres in area removed from the new layer, creating a layer of potential riparian mitigation sites greater than three acres in size.

Data Needs

1. Hydrography layer.

2. Available riparian coverages, current land cover, digital orthophotos, stereo-paired if available.

3. Study area, Stream Catchments, and DAU boundary layers.

4. Soil survey layer, C and D soils.

5. Land ownership layer or maps of publicly owned lands.

6. Local priority sites.

7. Wetland and floodplain potential mitigation sites (when available).

Products

1. An approximation of riparian condition and forested riparian area within the study area, stream catchments and DAUs.

2. A GIS data file of potential riparian mitigation sites within the study area, stream catchments and DAUs.

Step 3E. Determine Location, Extent, and Condition of Fish and Wildlife Habitats

Purpose

To determine the current state of ecological function of aquatic habitat at the landscape scale. The current state of aquatic habitat provides valuable insight on each of the five ecological processes that support functions to provide valuable aquatic habitat necessary to sustain healthy populations of salmonid species and other important aquatic life.

Methods

Stream catchments in the study area were evaluated based on their potential to maintain natural processes, thus to promote habitat that can support healthy runs of salmonid species. Following a watershed characterization of the five ecological and two biological processes, DAUs were identified as “not properly functioning”, “at risk,” and “properly functioning” for each of the five ecological processes.

1. Compile available results on the current condition of the five core ecological processes and two biological processes, developed in Part I, Step 4. These processes include:

- Delivery and routing of water
- Delivery and routing of large wood
- Delivery and routing of sediment
- Delivery and routing of pollutants
- Delivery and routing of heat
- Aquatic integrity
- Upland habitat connectivity

2. Develop a map of the study area with DAU boundaries delineated. Over each DAU, establish a circle. Divide the circle into the number of ecological processes that have a condition rank. For example, on the I-405 / SR-520 project, data were available on the condition rank for five of the seven ecological and biological processes. In this case, the circle was divided into five equal pieces and the condition rank of each process was visually portrayed as a color. Color code “properly functioning” as green, “at risk” as yellow, and “not properly functioning” as red.

Data Needs

1. Characterization results for all available ecological and biological processes.

Products

1. A map that details the current state of the five ecological processes in each DAU within the study area.

2. A narrative report summarizing the current state of aquatic habitat in the study area.

Step 3F. Establish Baseline Conditions for ESA Listed Species

Pending.

Step 4. Characterize Condition of Ecological and Biological Processes in Study Area

Purpose

Methods that characterize the condition of important ecological and biological processes produce results that can be used to:

- Help understand the landscape-scale condition of and constraints on aquatic and terrestrial resources and fish and wildlife habitats
- Establish a landscape context for assessing mitigation options and alternatives
- Help identify where landscape-scale indicators of natural resource degradation exist at multiple scales, further providing context for understanding project impacts and mitigation opportunities
- Help understand core problems that influence a site's capability to provide and maintain functions
- Establish the condition of habitat connectivity within stream catchments

Methods

1. Determine if a quantitative landscape-scale assessment of ecological processes has been done for drainages within the study area. When available, use this landscape scale information in the analysis to determine the condition ("properly functioning," "at risk," or "not properly functioning") of ecological processes (such as delivery and routing of water, sediment, pollutants, large wood, and heat) and biological processes (aquatic integrity and upland habitat connectivity).

2. When quantifiable data are not available, the interdisciplinary technical team identifies potential landscape indicators for each ecological process. Use Table 5 as a starting point for team discussions. At a minimum, compile or develop information when possible to complete the qualitative matrix of landscape-scale pathways and indicators (Table 5). We suggest that the most recent watershed characterization project report be reviewed to determine the attributes used to characterize the condition of each ecological and biological process.

3. When appropriate, review selected indicators with permitting agencies to ensure agreement on landscape indicators and indicator thresholds.

4. Characterize the condition of selected landscape attributes for each key ecological and biological processes. Characterization work should occur at the DAU scale, unless justification exists and is documented. Landscape attributes that have been used in past projects to characterize the condition of key ecological and biological processes include:

   Delivery of Water

- Calculate percent TIA for each DAU. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

- Calculate percent forest land cover for each DAU. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

- Determine the condition and extent of wetlands within each DAU. Calculate percent of wetlands hydrologically altered (drained or filled) within DAUs where wetlands represent five percent of more of the DAU. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

- Calculate percent change in drainage network for each DAU. The hydrologist on the technical team evaluates available data to determine the best attributes for assessing this landscape indicator. Examples of land uses that increase the drainage network include wetland drainage, floodplain drainage ditches, storm drains, and roadside ditches. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

Routing of Water

- Calculate percent channel length straightened for each DAU. Overlay hydrography datasets onto the DAU coverage and visually identify stream reaches that have potentially been straightened. Highlight potentially straightened stream reaches, overlay land use/land cover, and identify potentially straightened stream reaches with native vegetation and those with altered vegetation. Stream reaches with native vegetation should be assumed to have a natural stream configuration and were eliminated from further consideration. Stream reaches with agricultural, high density residential, or commercial/industrial land uses should be assumed to have an artificially straightened stream reach. Use aerial photography to support decision-making when uncertainty exists. Use GIS tools to calculate the percentage of stream channel that has been straightened. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

- Calculate percent of floodplain decoupled from the river channel for each DAU. Acquire available data on the location and extent of floodplain dikes and levees. Develop a GIS dataset that identifies that part of the floodplain that lies behind dikes and levees and has reduced opportunity to store and desynchronize flood flows and sediment. Use GIS tools to calculate the percentage of floodplain area decoupled. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

Delivery of Sediment

- Calculate percent bare soil areas for each DAU. A primary source of fine sediment in the Puget Lowland is assumed to be unvegetated or disturbed soil areas. Evaluate available land use/land cover datasets and identify land uses that are considered to have bare or disturbed soils. In general, all agricultural areas, including fallow, orchards / vineyards, pasture, row crops, and small grain crops are assumed to meet these criteria. Use GIS tools to calculate the percentage of bare soil areas within each DAU. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

- Calculate road density (road miles per square mile) for each DAU. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

- Refer to previously calculated results for percent channel length straightened and percent floodplain decoupled from a stream.

- Where less than five percent of the DAU consists of slopes greater than 30 percent, calculate the percent of unstable slopes in nonforest land cover. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

Delivery and Routing of Nutrients and Toxicants

- Determine the number of 303(d) listed water bodies for each DAU. Due to the limited ambient monitoring data, this landscape indicator should be used with caution. This information is excellent at indicating what DAUs are "not properly functioning." However, most streams do not have ambient monitoring data and we can't assume that streams without data are "properly functioning." If 303(d) data is limited for the study area, it should not be used as an indicator of condition for this ecological process. When adequate information is available, assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

Delivery of Large Wood

- Determine the percent of 67 meter riparian zone in mature forest for each DAU. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

Routing of Large Wood

- Determine the average number of stream crossings per kilometer of stream for each analysis unit. Assign a condition of "properly functioning," "at risk," or "not properly functioning" for this landscape indicator using criteria provided in Table 5.

Delivery and Routing of Heat

- Refer to previously calculated results for 303(d) listed water bodies, percent of 33 meter riparian zone in mature canopy, road density, and percent TIA.
- Additional methods in development

Aquatic Integrity

- Plot and evaluate available Benthic - Index of Biological Integrity (B-IBI) scores with the study area.
- Use previously calculated condition results of percent riparian area in forest land cover by DAU.
- Use previously calculated condition results of percent total impervious area by DAU.

Snyder et al. (2003) synthesized results of existing studies relating to the influence of upland and riparian land use patterns on stream biotic integrity. This paper notes that in studies where scale influences were tested, whole-catchment land use patterns were found to be better predictors of stream biological integrity in some studies, while others suggest riparian land use patterns were more influential. This information was used to support the use of both percent riparian area in forest land cover and percent total impervious area as landscape attributes for aquatic integrity.

Booth and others (2001) suggest that biological measures provide better information about environmental quality than chemical or physical measures because biological measures are one step closer to the factors that constitute environmental quality for living things. As a result of this work, B-IBI data were compiled and used when available, with best professional judgment, to modify the final condition rank of each DAU for aquatic integrity. Table 5 shows criteria for assigning aquatic integrity condition rank to DAUs.

Table 5. Criteria for Assigning Aquatic Integrity Condition Rank to DAUs.

Attribute	Attribute Priority	Possible Condition Rank
Benthic – Index of Biological Integrity	Primary	Scores of: 10-22 – Not Properly Functioning 24-40 – At Risk 42-50 – Properly Functioning
Percent Riparian Area in Forest	Secondary	As noted in Table 7
Percent Total Impervious Area	Secondary	As noted in Table 7

Habitat Connectivity

- Clip the Landsat-derived land cover data to the stream catchment boundaries.

- In raster format, create a layer of forest, non-forest and water classifications from the Landsat imagery, labeled per stream catchment. Forest and water are defined in Hill et al. (2003), and all other classifications will be referred to as non-forested. Grain size should be appropriate for the precision of the imagery and the size of the study area.

- Under an 8-neighbor rule, to encompass the most area per patch and include riparian systems, run FRAGSTATS with the metrics found in Table 6:

Table 6. FRAGSTATS-calculated landscape metrics used for this project.

Metric	**Name**	**Description**
AREA	Area	Area of each patch (ha)
CA	Class Area	Total class area within a landscape (ha)
TA	Total Area	Total landscape area (ha)
PLAND	Percent of Landscape	Percentage of landscape in class (%)
GYRATE_AM	Area-weighted Mean Radius of Gyration	The area-weighted mean radius of gyration, correlation length, the average distance traversed from a random starting point in a random direction with in a landscape, its traversability.
COHESION	Patch Cohesion Index	Physical connectedness of patches in a class, approaches 0 as class becomes less aggregated (comparative value)

(For more detail, consult the I-405 / SR-520 Case Study or McGarigal et al. 2002).

- Export the data to a spreadsheet and use the results from FRAGSTATS to calculate the total forested area per stream catchment. This creates an approximation of habitat condition and forested area within the study area and individual stream catchments.

- Rank the stream catchments by PLAND value, weighted by GYRATE_AM, and compare it to the COHESION index. Catchments with a COHESION index higher than 90 percent and a PLAND greater than 41 percent are considered “properly functioning.” Catchments with greater than 90 percent COHESION but a PLAND of less than 41 percent are considered “at risk.” All other catchments, below 90 percent COHESION are considered “not properly functioning.” Catchments with a large GYRATE_AM score that are near either border of the “at risk” category should be assessed individually, and reassigned if appropriate. This creates a baseline rating of habitat connectivity for each stream catchment. See the I-405 / SR-520 Case Study for more information on the landscape metrics we use.

5. For each key ecological and biological process, compile and display the condition of all landscape indicators, by process. Develop a map of the study area with DAU boundaries. Use GIS tools to place a circle on each DAU. Divide each circle into the number of landscape indicators used to assess the condition of each ecological or biological process. Color-code each part of the circle with the results of one landscape indicator. Color-code those indicators that are “properly functioning” (green), “at risk” (yellow), and “not properly functioning” (red).

6. Produce map displaying color-coded circles by DAU summarizing the condition of landscape indicators used to characterize each ecological and biological process. Assemble interdisciplinary technical team. Discuss available landscape indicators for each process and identify key drivers. Review landscape attribute results and develop rules for establishing an overall condition for each ecological and biological process. Rules and rule assumptions developed for each key process from past projects are presented in Tables 9 - 12. Then, using established rules, evaluate the condition rank of each landscape indicator, by DAU, and assign an overall rank score of “properly functioning,” following all established rules.

7. Using data on landscape indicator condition and rules developed earlier, establish an overall condition rank by DAU for each ecological and biological process. Display results by color-coding each DAU by condition rank: green – “properly functioning,” yellow – “at risk,” and red – “not properly functioning.”

8. Calculate percent total impervious under future land use conditions, using the future buildout scenario developed earlier,. Then substituting existing percent TIA totals with future percent TIA calculations by DAU, develop a second study area map for the delivery and routing of water, displaying the condition rank of all landscape indicators using pie-type color-coded circles. Then establish an overall condition rank for each DAU for the delivery and routing of water, using the same rules and assumptions employed earlier.

9. Determine if a quantitative landscape-scale assessment of habitat conditions for ESA listed species has been done for drainages within the study area. When available, use this information at the landscape scale used in the analysis to determine the condition (“properly functioning,” “at risk,” or “not properly functioning”) of habitat conditions.

10. When quantifiable data are not available, the interdisciplinary technical team identifies potential landscape indicators for habitat condition. Use Table 7 as a starting point for team discussions. At a minimum, compile or develop information when possible to complete the qualitative matrix of landscape-scale habitat pathways and indicators (Table 7) and matrix addendum of landscape-scale habitat pathways and indicators (Table 8).

11. Review selected indicators with permitting agencies to ensure agreement on landscape indicators and indicator thresholds.

12. Provide results to local technical recovery team, when available, to review and comment on results. Revise results to reflect recovery team understanding.

Data Needs

1. GIS datasets of DAUs
2. GIS datasets of floodplain boundaries
3. Hydrography
4. Most current land cover classified Landsat imagery of the study area
5. Digital Elevation Model data (10-meter)
6. Wetland inventory and condition data
7. GIS datasets of roads
8. GIS datasets of dikes, levees, and rip rap
9. 303(d) listed water bodies
10. ESA listed species distribution and habitat data
11. Fish barriers datasets
12. Data on habitat refugia
13. Data on biodiversity
14. Study area and stream catchment boundary layers
15. FRAGSTATS version 3.3 (McGarigal et al. 2002)

Products

1. Database or spreadsheet listing the rank condition of each DAU for all ecological and biological processes characterized.
2. A color-coded map displaying the results by DAU or stream catchment of the characterization of each ecological and biological process.

Table 7. Matrix of Landscape-scale Pathways and Indicators.

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
Delivery of Water to a Stream System	1) Percent change in Drainage Network [1]	Reduces Delivery Time; Habitat Degradation	All Units	Zero or minimal increases (<5%) in drainage network density due to development	Moderate increases (5% to 20%) in drainage network density due to development	Substantial increase (>20%) in drainage network density due to development
	2) Percent TIA [2]	Reduces Delivery Time; Increases Amount of Water Delivered; Habitat Degradation	All Units	5% or less TIA	>5% and <30% total imperious area	≥30% TIA
	3) Percent Forest Land Cover [3]	Reduces Delivery Time; Increases Amount of Water Delivered; Habitat Degradation	All Units	>65% of area in mature forested land cover and non-forested areas scattered throughout	50% to 65% of area in mature forested land cover with some larger areas of non-forest land cover	<50% in mature forested land cover with large continuous areas of non-forest land cover

[1] Narrative criteria for indicator condition taken from US Fish and Wildlife Service (1998), numeric criteria added by authors

[2] Revised 8/04 based on Booth, D.B., J.R. Karr, S. Schauman, C.P. Konrad, S.A. Morley, M.G. Larson, and S.J. Burges. In Press. Reviving Urban Streams: Land Use, Hydrology, Biology, and Human Behavior. Journal of the American Water Resources Association. Further rationale presented in Appendix XX

[3] NOAA Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA Fisheries Service, Northwest Region.

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
	4) Condition and Extent of Wetland Resources[4]	Loss of assimilative capacity	Primarily areas having minimal groundwater recharge capacity	>95% of all historic connecting wetland capacity present and unaltered	70-95% of historic connecting wetland capacity present and unaltered	<70% of historic connecting wetland capacity present and unaltered
Routing of Water Through a Stream System	5) Percent of Channel Length Straightened	Reduced Routing Time; Habitat Degradation	All Units	Zero or minimal increases (<5%) of natural drainage network straightened	Moderate increases (5% to 20%) in natural drainage network straightening	Substantial increase (>0%) in drainage network straightening
	6) Percent of Floodplain Decoupled from Stream [5]	Reduced Routing Time; Habitat Degradation	Only units with unconfined or partially confined channel	Zero or minimal increases (<5%) in decoupled floodplain	Moderate increases (5% to 20%) in decoupled floodplain	Substantial increase (>20%) in decoupled floodplain
Delivery of Sediment to a Stream System	7) Percent of Bare Soil Areas in Non-forest Areas	Increased Fine Sediment Inputs; Habitat Degradation	All Units	<5% of area in land uses having bare soils s	5-15% of area in land uses having bare soils	>15% of area in land uses having bare soils

[4] NOAA Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA Fisheries Service, Northwest Region

[5] Narrative criteria for indicator condition taken from NOAA-Fisheries (1996) and US Fish and Wildlife Service (1998), numeric criteria added by authors

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
	8) Road Density [6]	Increased Fine and Coarse Sediment Inputs; Habitat Degradation	All Units	Road densities < 2 miles/square mile	Road densities of 2-3 miles/square mile	Road densities > 3 miles/square mile
	9) Unstable Slopes	Increased Inputs of Fine and Course Sediment	Glacial Deposits	≥5% of DAU in > 30 percent slope and <10 percent of high slope area in non-forest land cover	≥5% of DAU in > 30 percent slope and ≥10%< 25% of high slope area in non-forest land cover	≥5% of DAU in > 30 percent slope and ≥25% of high slope area in non-forest land cover
Routing of Sediment Through a Stream System	8) Percent of Channel Length Straightened	Reduced Routing Time; Habitat Degradation	All Units	Zero or minimal increases (<5%) of natural drainage network straight-ened	Moderate increases (5% to 20%) in natural drainage network straighten-ing	Substantial in-crease (>20%) in drainage network straightening
	9) Percent of Flood-plain Decoupled from Stream [7]	Reduced Routing Time; Reduced Access to Habi-tat	Only units with un-confined or partially confined channel	Zero or minimal increases (<5%) in decoupled flood-plain	Moderate increases (5% to 20%) in decoupled flood-plain	Substantial in-crease (>20%) in decoupled flood-plain

[6] Narrative and numeric criteria for indicator condition taken from NOAA-Fisheries (1996)

[7] Narrative criteria for indicator condition taken from NOAA-Fisheries (1996) and US Fish and Wildlife Service (1998), numeric criteria added by authors

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
Delivery and Routing of Nutrients, Toxicant, and Bacteria to a Stream System	10) Extent of 303(d) Listed Water Bodies for Nutrients, Toxicants, and Bacteria [8]	Documented Water Quality Problem	All Units	Area meets water quality standards for all parameters. No excess nutrients or toxicity.	Water quality in the area has one parameter that exceeds water quality criteria by 10 percent or greater	More than one parameter exceeds water quality criteria by 10 percent or greater. Sub-lethal and lethal effects from toxics.
	11) Condition and Extent of Wetlands[9]	Loss of assimilative capacity	Primarily areas having minimal groundwater recharge capability	Historic wetland area >5% and <25% of wetlands have been drained or hydrologically altered	Historic wetland area >5% and 25% to 40% of wetlands have been drained or hydrologically altered	Historic wetland area >5% and >40% of wetlands have been drained or hydrologically altered
Delivery of Large Wood to a Stream System	12) Percent of 67 meter Riparian Zone in Mature Condition [10]	Source of Large Wood to the Stream System; Habitat Degradation	All Units	85% of overall riparian zone in forest or wetland cover	50-85% of overall riparian zone in forest or wetland cover	<50% of overall riparian zone in forest or wetland cover

[8] Narrative criteria for indicator condition taken from NOAA-Fisheries (1996) and US Fish and Wildlife Service (1998)

[9] NOAA-Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA-Fisheries Service, Northwest Region

[10] Adapted from NOAA-Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA-Fisheries Service, Northwest Region

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
Routing of Large Wood Through a Stream System	13) Stream Cross-ings/Kilometer[11]	Blocks Routing of Large Wood and Facilitates Removal from System; Habitat Degradation	All Units	< 2 – 20 meter stream crossings per kilometer of stream	2 to 4 – 20 meter stream crossings per kilometer of stream	> 4 – 20 meter stream crossings per kilometer of stream
Delivery and Routing of Heat to a Stream System	14) Extent of 303(d) Listed Water Bodies for Temperature [12]	Identifies Problem Areas but Does Not Address Causes; Habitat Degrada-tion	All Units	Area meets water quality standards for temperature	One parameter that exceeds tempera-ture criteria 10 percent or more of the time	More than one parameter exceeds temperature crite-ria 10 percent or more of the time
	15) Percent of 33 meter Riparian Zone with Mature Canopy [13]	Increase in Solar Energy to Stream; Habitat Deg-radation	* Stream width > XX feet or units with significant groundwater dis-charge excluded	85 percent or more of channel with riparian canopy intact and no large continuous stretches of open canopy	50 to 85 percent of riparian canopy intact but having some continuous stretches of open canopy	Riparian canopy fragmented, > 50 percent and con-tains large con-tinuous stretches with no canopy

[11] NOAA-Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA-Fisheries Service, Northwest Region

[12] Based on common criteria established by NOAA-Fisheries (1996) and the U.S. Fish and Wildlife Service (1998) for chemical contamination/nutrients

[13] Adapted from NOAA-Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA-Fisheries Service, Northwest Region

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
	16) Road Density [14]	Reduced Stream ; Habitat Degradation Depth	* Stream width > XX feet or stream order X or less only	Road densities < 2 miles/square mile	Road densities of 2-3 miles/square mile	Road densities > 3 miles/square mile
	17) Percent TIA [15]	Change in Groundwater Recharge/ Discharge; Habitat Degradation	Primarily Units with a Surficial Aquifer	5% or less TIA	>5% and <30% TIA	30 percent or more TIA
Biological Integrity	18) Benthic – Index of Biological Integrity	Overall Habitat Condition	All Units	Benthic – Index of Biological Integrity score ≥42	Benthic – Index of Biological Integrity score of 24 to 40	Benthic – Index of Biological Integrity score < 24
	19) Percent of 67 meter Riparian Zone in Mature Condition[16]	Buffers Effects of Upland Disturbance	All Units	85% of overall riparian zone in forest or wetland cover	50-85% of overall riparian zone in forest or wetland cover	<50% of overall riparian zone in forest or wetland cover

[14] Narrative and numeric criteria for indicator condition taken from Stelle (1996)

[15] Revised 8/04 to better reflect findings in Booth, D.B., J.R. Karr, S. Schauman, C.P. Konrad, S.A. Morley, M.G. Larson, and S.J. Burges. In Press. Reviving Urban Streams: Land Use, Hydrology, Biology, and Human Behavior. Journal of the American Water Resources Association.

[16] Adapted from NOAA-Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA-Fisheries Service, Northwest Region

Ecological Process	**Landscape Indicator**	**Effect**	**Applicable Lithotopo Units**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
Upland Habitat Connectivity	20) Level of Habitat Connectivity	Risk of Habitat Isolation	All Units	Use methods described elsewhere using Fragstats	Use methods described elsewhere using Fragstats	Use methods described elsewhere using Fragstats

* These Indicators require additional work at time of publication, and exact numbers are not available – if needed, contact authors for more information.

Table 8. Matrix Addendum of Landscape-scale Habitat Pathways and Indicators.

Pathway	Landscape Scale	Landscape Indicator	Effect	Properly Functioning	At Risk	Not Properly Functioning
General Stream / Habitat Condition	Stream Catchment	1) Refugia[1]	Intact habitat serves as core area that maintains viable fish populations and serves as the foundation for recovery efforts	Habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia sufficient in size, number and connectivity to maintain viable populations	Habitat refugia exist but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number, and connectivity to maintain viable populations	Adequate habitat refugia do not exist
		2) Proportion of floodplain stream channel artificially confined	Loss of Floodplain Channel Complexity; Habitat Degradation	<5% of channel length having high energy river bends confined by armoring or dikes	5 to 25% of channel having high energy river bends confined by armoring or dikes	>25% of channel having high energy river bends confined by armoring or dikes
Stream Health	Stream Catchment	3) Aquatic Integrity	An overall indicator of stream condition	>50% of DAUs in the stream system have an Aquatic Integrity rank of “properly functioning” and no DAUs are ranked as “not properly functioning”	>50% of DAUs in the stream system have an Aquatic Integrity rank of “properly functioning” or “at risk”	>50% of DAUs in the stream system have an Aquatic Integrity rank of “not properly functioning”

[1] Narrative criteria for indicator condition taken from NOAA-Fisheries (1996)

Pathway	**Landscape Scale**	**Landscape Indicator**	**Effect**	**Properly Functioning**	**At Risk**	**Not Properly Functioning**
Access to Habitat	Stream Catchment	4) Stream Crossings/Kilometer; Number of Fish Passage Barriers[2]	Restrictions to Fish Passage	No artificial hydraulic constrictions (culverts, bridges, dams) that disrupt upstream and downstream year-round migration of juvenile and adult salmon	Hydraulic constrictions exist but allow for year-round access to at least 80 percent of potential spawning and rearing habitat	Hydraulic constrictions exist and limits access to greater than 20 percent of potential spawning and rearing habitat
	Stream Catchment	5) Condition of wetlands historically accessible to ESA listed fish species	Degradation of Off-channel Rearing Habitat	> 95 percent of historic connecting wetland capacity present and unaltered	70-95 percent of historic connecting wetland capacity present and unaltered	< 70 percent of historic connecting wetland capacity present and unaltered

[2] NOAA-Fisheries Service. March, 2003. HCD Stormwater Online Guidance, ESA Guidance for Analyzing Stormwater Effects. NOAA-Fisheries Service, Northwest Region

Table 9. Rule Examples and Rule Assumptions Used To Establish and Overall Condition Rank For The Delivery and Routing of Water.

Example of water rules when percent TIA, percent forest cover, and condition/extent of wetlands were used as landscape indicators	When two of three landscape indicators are “not properly functioning”, the final rank is “not properly functioning”.
	When percent TIA is “not properly functioning”, percent forest cover is “at risk”, and wetlands are not a landscape indicator, the final rank is “not properly functioning.”
	When both percent TIA and percent forest cover are “at risk”, the final rank is “at risk.”
	When percent TIA is “at risk”, percent forest cover is “properly functioning”, and wetlands are not an indicator, the rank is “at risk.”
	When TIA is “at risk” or “properly functioning” and the other landscape indicators has a different condition rank (i.e., “properly functioning”, “at risk”, and “not properly functioning”), the final rank is “at risk.”
	When percent TIA is “properly functioning”, percent forest cover is “not properly functioning”, and wetlands are not an indicator, the final rank is “at risk.”
	When percent TIA is “at risk”, percent forest cover is “not properly functioning”, wetlands are “not properly functioning, and a large lake/wetland system existing in the DAU, the final rank is “at risk.”
	When both percent TIA and percent forest cover are “properly functioning”, the final rank is “properly functioning.”
Water Rule Assumptions	Percent TIA is considered the strongest condition indicator of the delivery of water in the Puget Lowland.
	Percent forest cover is both the second strongest condition indicator of the delivery of water and a potential buffer to other problems associated with the delivery of sediment and pollutants.

	Wetlands are assumed to be the third strongest condition indicator of the delivery of water in DAUs where wetlands historically comprised five percent or more of the DAU.
	Large lake or wetland systems within a DAU will reduce the effects the land cover alteration has on the delivery of water to a stream system.
	Some combination of landscape indicators may be good for recovery purposes but less desirable for mitigation purposes. Develop assumptions used in rule making then establish rules to identify sites that first mitigate transportation impacts and second maximize environmental benefits.

Table 10. Rule Examples and Rule Assumptions Used To Establish and Overall Condition Rank For The Delivery and Routing of Sediment.

Example of sediment rules when percent bare soil, unstable slopes, and road density are used as landscape indicators	When two or more indicators are "not properly functioning", the final rank is "not properly functioning."
	When two or more indicators are "at risk", the final rank is "at risk".
	When any combination of indicators has a different condition rank (i.e., "properly functioning", "at risk", and "not properly functioning"), the final rank is "at risk." When two indicators are "properly functioning" and one is "not properly functioning", the final rank is "at risk."
	When road density is "not properly functioning", bare soils are either "properly functioning" or " at risk", and unstable slopes is not an indicator, the final rank is "at risk."
	When two indicators are "properly functioning" and one is "at risk", the final rank is "at risk."
	When road density and bare soils are "properly functioning" and unstable slopes are either "properly functioning" or not evaluated, the final rank is "properly functioning."
Sediment Rule Assumptions	The most effective measures to control sediment are source-based. Focus should be on where recovery conditions optimize the restoration to the delivery of sediment.
	Percent bare soils is considered the strongest condition indicator of the delivery of sediment in the Puget Lowland where they exist.
	Percent unstable slopes in non-forest land cover and road density are indicators that equally represent the second strongest condition indicator of the delivery of sediment. It is assumed that road density is the primary indicator of sediment delivery in mountainous bedrock areas where roads intersect colluvial deposits.

Table 11. Rules and Rule Assumptions Used To Establish and Overall Condition Rank For The Delivery and Routing of Large Wood.

Example of large wood rules when percent riparian forest and stream crossings are used as landscape indicators	When riparian forest condition is the sole indicator of the delivery of large wood, then its condition rank will be the overall rank.
Large Wood Rule Assumptions	Focus on the landscape indicator for the delivery of wood to a stream. The condition of the landscape as it relates to her routing of wood is only important if wood is being recruited to the stream system.
	Condition of the 67-meter riparian buffer is assumed to represent the overall condition of the delivery of wood to a stream system.

Table 12. Rule Examples and Rule Assumptions Used To Establish and Overall Condition Rank For Aquatic Integrity.

Example of aquatic integrity rules when B-IBI, percent riparian forest and percent TIA are used as landscape indicators	Due that the variability in B-IBI scores within the same DAU, some interpretation and the use of best professional judgment is required. When multiple data points exist in the same DAU or stream reach, we used upstream to downstream score trends rather than simple score averaging to establish a B-IBI score.
	B_IBI condition rank dominated the overall condition rank unless secondary and tertiary indicators substantially differed from B-IBI.
Aquatic Integrity Assumptions	Condition of the benthic community is assumed to represent the overall condition of aquatic biological integrity.
	B-IBI is considered to be the strongest landscape indicator of those available to characterize aquatic integrity, because it is a biological attribute rather than a physical attribute. We assume that the condition of biological indicators is one step closer to a true measure of aquatic integrity when compared to physical attributes at landscape scales.
	In DAUs where percent TIA is less than 30%, we assume that percent riparian forest is a secondary indicator and percent total impervious area a tertiary indicator.
	In DAUs where %TIA is greater than 30%, B-IBI is considered to be the primary landscape attribute, with riparian forest condition and %TIA as secondary attributes.

Step 5. Interdisciplinary Integration

Purpose

Develop an understanding of the landscape surrounding our project and how it functioned in a pre-develop condition compared to current conditions. Identify and better understand the inter-relationships between physical, biological, and chemical components of the study area. Establish general cause and effect relationships between resource degradation and human land use. Identify general areas or criteria for targeting restoration efforts. Gain understanding of the types of environmental impacts within the project area that can be anticipated. Generally quantify area and function of resources affected.

Methods

At the beginning of a project, the interdisciplinary technical team works independently to study and compile information on the project and study areas from their individual areas of expertise. Key subject areas should be assigned to team members to ensure that all major resource areas are covered. Following independent study, schedule a six to eight hour meeting with the technical team to share and begin the process of integrating the technical disciplines and understanding.

At the beginning of this meeting, encourage all technical team members to consider these three key components of ecosystems in their discussion:

- Composition (what is there)
- Structure (how is it distributed in time)
- Function (what it does)

Our purpose is to develop an understanding of ecological processes and how they contribute to sustaining ecological integrity and key functions (species, habitats, and services) of importance.

First, focus on individual ecological processes and how they can be affected by human activities through cause and effect. At the same time, maintain an ecological mindset that focuses on the interconnectedness of processes in each DAU.

Assign individual technical team members one or more of the following subject areas to prepare and present to the interdisciplinary technical team. Subject areas should be added or deleted when appropriate. It is suggested that 30 to 60 minutes be scheduled for presentations and discussion on each subject area. The following subject areas are suggested:

Characterize the study area:

1. Surface/Sub-surface water movement – Surficial Geology
    - Pre-development conditions
    - Current conditions

- Degradation factors

2. Upland Conditions
   - Pre-development conditions – forest/non-forest
   - Current conditions – Extent of human development/TIA by DAU
   - Degradation factors
   - Future conditions – GMA build-out scenario
3. Wetland Conditions
   - Pre-development conditions
   - Current conditions by DAU
   - Degradation factors
4. Riparian Conditions
   - Pre-development conditions
   - Current conditions by DAU
   - Degradation factors
5. Water Quality Conditions
   - Current conditions
   - Degradation factors
6. Fish Habitat Conditions
   - Pre-development conditions
   - Current conditions
   - Degradation factors
7. Biological Conditions
   - Past and present B-IBI conditions
8. Local Recovery Priorities

Site Characterization of Environmental Impacts to Project Area:

1. Stormwater Impacts (Water Quantity)
2. Stormwater Impacts (Water Quality)
3. Potential Wetland Impacts
4. Potential Riparian Impacts
5. Potential Impacts to Streams/Fish Habitat
6. Summary of Anticipated Environmental Impacts

At the end of all presentations and subject area discussions, additional discussion should follow on putting site-specific impacts into a landscape context.

Data needs

All available data on the project and study areas.

Products

1. Landscape context for project impacts.
2. Better understanding of the inter-relationships between the physical and biological sciences within the study area.
3. A list of ecological processes to be targeted for out of right-of-way mitigation.

Step 6. Estimate Pre-Project Cumulative Impacts of Land Use

Purpose

Understanding the cumulative impacts of human land use on natural resources provides important context in which to assess potential project impacts and mitigation options. This step begins to develop that context to ensure that potential project impacts are adequately mitigated and mitigation opportunities have increased potential to maximize environmental benefits and reduce cost.

Methods

1. Assemble ecological process condition maps displaying the condition of all landscape attributes used to establish an overall condition rank for each ecological process.

2. Present these results visually and numerically to the interdisciplinary technical team.

3. Evaluate the change in landscape attributes at a project scale, such as TIA and percent forest land cover, when the project is added to the landscape. Technical team uses best professional judgment to develop assumptions regarding the projects contribution to the degradation of key ecological processes.

4. Evaluate the condition of ecological processes within the study area using landscape attributes, such as TIA and percent forest land cover. Technical team uses best professional judgment to develop the rationale for identifying DAUs that warrant increased focus for restoration actions.

Data needs

Maps summarizing the condition of all landscape attributes used to characterize ecological processes.

Product

1. Information that provides understanding of the cumulative effects of land use on natural resources within the project area and of the project's potential contribution to further degradation at landscape scales.

2. Information that can be used to help guide the prioritization and selection of potential mitigation sites in light of the surrounding land use impacts of each site.

Step 7. Establish Baseline Conditions for ESA-listed Species

Pending.

Methods Part II. Project Site Assessment

The Approach

The second part of three sets of characterization steps focuses on understanding the potential environmental impacts of the transportation project. The following questions are addressed:

1. Where do areas of high environmental function exist where impacts should be avoided or minimized?

2. Where does the potential to mitigate unavoidable impacts in the right-of-way exist?

Step 1. Establish Limits of Construction

Purpose

The project boundaries are needed to estimate potential direct impacts of the project on natural resources.

Methods

Acquire anticipated limits of construction or potential right-of-way alternatives from project engineers. Convert to GIS format.

1. Get limits of construction from project engineers in a computer-aided drafting file format such as .dgn. If limits of construction are not yet available, the project area can be estimated from site visits and aerial photo interpretation. Alternatively, a simple line segment taken from the Washington State Routes data layer will suffice.

2. Convert to an ArcView shapefile.

3. Use ArcView to convert the shapefile into a coverage.

Data Needs

Local and extent-of-project alternatives

Product

A GIS layer depicting the anticipated project boundaries of the alternatives.

Step 2. Engage Local Watershed Groups and Establish Recovery Themes

Purpose

This step seeks to develop a good working relationship with staff for such groups as local watershed planning units and Native American Tribal governments, acquire documents and/or GIS data layers to use for creating a locally-developed priority list of restoration sites (see Part III, Step 2), and gain insight into local watershed priorities and needs necessary to help establish watershed themes for mitigation (see Part III, Step 1).

Step 2A. Engage Local Watershed Groups

Purpose

1. Develop a good working relationship with staff for such groups as local watershed planning units and Native American Tribal governments for consultation on a variety of issues throughout the characterization, including establishing locally determined themes for recovery (see Part II, Step 2B).

2. Develop and continue to update a list of e-mail addresses of interested parties in those groups and others for status reporting and meeting announcements.

3. Acquire documents and/or GIS data layer to use for creating a locally-developed priority list of restoration sites (Part III, Step 2)

Methods

1. Meet and coordinate with local watershed planning groups representing Watershed Planning Act (often called “2514 groups”) planning units, Salmon Recovery Act (often called “2496 groups”) groups, state agencies working on local watershed recovery efforts, Native American Tribal governments, and other groups where appropriate.

2. Continue to arrange special meetings between the groups discussed above and technical team members as needed.

3. Send concise status reports by e-mail every one to two weeks to keep the groups informed about progress, meetings, opportunities to help, and products to share.

4. Consult draft and completed reports containing watershed priorities for habitat restoration, salmonid recovery, water quantity, and base flow improvements, and water quality improvements to identify sources of information about local priorities.

5. Arrange a “debriefing” meeting with local groups when preliminary results are available if this appears to be of interest to the local agency staff.

6. Produce periodic status reports to keep local staff informed about the progress of the characterization.

Data Needs

1. Data collected by local watershed planning groups

2. Reports (published, draft, or unpublished) produced by local watershed planning groups

Products

- Good working relationship with local groups.

- Watershed priority data for use in Part III, Step 2.

- Assistance on a variety of issues as needed.

Step 2B. Establish Recovery Themes

Purpose

To gain insight into local watershed priorities and needs necessary to help establish watershed themes for mitigation (Part III, Step 1).

Methods

1. Consult draft and completed reports containing watershed priorities for habitat restoration, salmonid recovery, water quantity, and base flow improvements, and water quality improvements to identify sources of information about local recovery themes.

2. Create a draft list of primary and secondary local recovery themes by catchment based on locally produced documents.

3. Send this list as part of a status report (see Part II, Step 2A) for review, comments, etc. At the same time, arrange a meeting in the watershed area to allow face-to-face discussion on the themes for recovery.

4. Finalize the list of primary and secondary local recovery themes by catchment.

Data Needs

1. Data collected by local watershed planning groups

2. Reports (published, draft, or unpublished) produced by local watershed planning groups

3. Data collected by personal meetings and communications with representatives of local watershed planning groups, etc.

Products

1. Recovery themes to use in Part III.

Step 3. Identify Project Impacts on Aquatic and Terrestrial Resources

Purpose

Compile information on the location and extent of aquatic and terrestrial natural resources and biological and chemical attributes of the project right-of-way and between the right-of-way and a 300’ buffer. Information within the 300-foot buffer is compiled to analyze resource impacts from an estimated future build-out scenario.

Methods

1. Identify aquatic and terrestrial resources regulated by local, state, and federal agencies.

2. Identify aquatic and terrestrial resources of local significance.

3. Identify and acquire information, data sets, and GIS data layers on wetlands, water bodies, potential riparian areas and buffers, FEMA 100-year floodplains, hydrologic soil groups, critical aquifer recharge areas, key geological features such as surficial geology, erosion hazard and seismic areas, and forested, grass, crop and bare soil areas.

4. Identify aquatic and terrestrial resources of special significance to local Native American Tribes within the project right-of-way.

5. Identify and acquire information on biological and chemical attributes of the project right-of-way.

6. Evaluate reliability of available data and supplement with new data when reliability is poor.

7. When multiple data sets are available for the project right-of-way, use local watershed planning groups and local jurisdictions to gain insight into the relative value of each.

8. When data sets are not available, the technical team will identify and select the option to be used to acquire or compile necessary data.

9. Convert each data set to a GIS data layer.

Data Needs

1. Wetland inventories and function assessments/characterizations.

2. Riparian resources and buffer areas.

3. Floodplain area and resources.

4. Local/Regional Groundwater Aquifers, areas of groundwater recharge and discharge, critical aquifer recharge areas and groundwater flow paths.

5. Water body resources.

6. Hydrologic soil groups.

7. Surficial geology.

8. Sensitive areas such as bogs, fens, or vernal pools, and other unique aquatic or terrestrial resources of regulatory importance or of local significance.

9. Critical areas such as geologically hazardous areas, seismic areas and frequently flooded areas.

10. Forested, grass, shrub, crop and bare soil areas.

Products

A series of GIS data layers of aquatic and terrestrial resources within the project right-of-way and between the right-of-way and the 300-foot buffer.

Step 4. Identify Special Species and In Right-of-Way Habitats

Purpose

Identify the location and habitat of regulated fish and wildlife species occurring within the project right-of-way.

Methods

1. Identify and acquire information and GIS coverages of ESA listed fish, wildlife, and plant species that are know to occur within the project right-of-way.
2. Identify and acquire information and GIS coverages of other species that occur on the project right-of-way and are regulated under local ordinance or state law.
3. Identify fish, wildlife, and plant species of special significance to local Native American Tribes within the project right-of-way.
4. Evaluate reliability of available data and supplement with new data when reliability is poor.
5. When multiple data sets are available for the project right-of-way, use local watershed planning groups, local jurisdictions, and regulatory agencies to gain insight into the relative value of each.
6. When data sets are not available, the technical team will identify and select the option to be used to acquire or compile necessary data.
7. Convert each data set to a GIS coverage.

Data Needs

1. ESA listed species and species habitat distribution and abundance.
2. Non-ESA regulated species and species habitat distribution and abundance.
3. Species of special significance to Native American Tribes.

Products

A series of GIS data files of key fish, wildlife, and plant species and species habitats located within the project right-of-way.

Step 5. Estimate Direct Impacts to Regulated Resources

Purpose

This step summarizes potential construction impacts of the transportation project to regulated natural resources within the project right-of-way.

Methods

1. Quantify the maximum potential impact to wetlands, riparian areas, and floodplains resources within the project right-of-way.

2. Quantify the maximum potential habitat losses to ESA listed species and other regulated fish, wildlife, and plant species, including habitat connectivity.

Data Needs

Results from Steps 3 and 4 above.

Product

A table summarizing maximum potential direct impacts to regulated natural resources and rare species.

Step 6. Assess Functions Provided by Impacted Resources

Purpose

Assess and quantify the functions of each regulated natural resource having a potential of direct impacts from the project. Step 7 quantified the type and area of direct natural resource impacts. This step seeks to quantify the specific resource functions lost through those impacts.

Methods

1. Identify function assessment work completed within the project area and also the tool/methodology used to make the assessments.

2. When function assessment work on natural resources within the project area has not been undertaken, identify available qualitative function assessment methods for doing this.

3. When function assessment options are limited or non-existent, explore the use of landscape-scale wetland function assessment tools developed by Gersib (2001) or those developed by WSDOT (2000).

Data Needs

Function assessment information for natural resources within the project right-of-way.

Product

A table summarizing natural resources impacted by the project, the impacted acreage of each resource, and the functions each resource unit is providing.

Step 7. Estimate Stormwater Impacts of Project

Purpose

Transportation projects will often have impacts to the quality and quantity of stormwater runoff. These impacts are mitigated through treatment and control of stormwater runoff. This step quantifies project impacts to water quality and quantity, and identifies the flow control and stormwater treatment functions that must be provided by mitigation alternatives.

Step 7A – Coordination with Ecology Technical Staff

Purpose

The Department of Ecology has primary responsibility for regulating and permitting stormwater discharges in Washington. Therefore, it is critical to coordinate with Ecology staff to get their perspectives on project impacts and mitigation requirements. Early involvement by Ecology technical staff increases the likelihood that mitigation alternatives will be successful.

Methods

1. Identify a primary contact from the Department of Ecology. This person will attend periodic technical team meetings and should be familiar with technical and regulatory issues associated with stormwater. The contact person will also provide routine updates on our work to other Ecology staff.

2. Present findings to Ecology technical staff at key project milestones. This gives them the opportunity to provide input and interact directly with the project technical team.

Data Needs

None.

Products

Periodic project updates to Ecology technical staff.

Step 7B – Quantify Contributing Areas for Stormwater Discharge

Purpose

In this step we identify water bodies that could be directly affected by stormwater from the project area. We delineate drainage boundaries and estimate the portion of the project area that contributes stormwater to each water body.

Methods

1. Overlay the project area onto the best available hydrography data layers. Identify all streams, lakes, and coastal waters that could receive direct discharge of stormwater runoff from the project.

2. Identify all fish-bearing streams that are intersected by the project.

3. Use topographic mapping, storm drainage maps, and basin planning maps to delineate drainage boundaries for each impacted water body. Local storm drainage maps are particularly important in urban areas where topographic drainage patterns have been altered by land development.

4. Calculate the portion of the project area that drains to each water body.

5. Estimate the TIA for the portion of the project within each drainage basin. If project-specific data are not available, paved areas can be estimated using standard lane and shoulder widths.

6. Compare the project TIA to the existing TIA in each drainage basin.

Data Needs

1. Map of the project limits.

2. Hydrography maps.

3. Topographic and storm drainage maps.

Products

1. A map of the drainage basins impacted by the project.

2. Project area and project TIA within each drainage basin.

3. Increase in TIA due to the project in each drainage basin.

Step 7C – Estimate Effects to Water Quality

Purpose

Quantify the potential stormwater impacts of the project on pollutant loads before any in right-of-way or out of right-of-way mitigation options (stormwater best management practices) are considered.

Rationale

To assess the stormwater impacts of a transportation project in advance of project construction, the responsibility is on the developer to provide the documented technical basis to verify that the project will comply with state water quality standards (White 2002). This step seeks to quantify the project impacts to water quality prior to exploring appropriate mitigation options.

Methods

1. Identify the primary stormwater constituents for stormwater runoff generated by the transportation project.

2. Identify all the water bodies that will potentially receive stormwater discharges from the project area.

3. Identify the pollutants of concern and stream reaches with unstable, eroding banks for the water bodies identified in method 2 using existing studies and data from state and local governments.

4. Using available modeling tools, quantify the volumes of surface water runoff that will be generated by the proposed project. Flow volumes are needed for pollutant load calculations.

5. Using available modeling tools, quantify the loading rates for all pollutants of concern from the proposed transportation project on each receiving water body.

Specific methods follow:

Stormwater impacts on the natural environment can be categorized as either flow or water quality impacts. Flow impacts are caused by a change in the water balance caused by increasing impervious areas that results in increased runoff peak flows, increased high flow durations, and limited infiltration capacity. Water quality impacts are the discharge of pollutants from the highway right-of-way and are caused by pavement degradation, vehicle exhaust, tire wear, chassis wear, auto body wear, and atmospheric deposition . The impacts can be quantified as increased peak flow in cubic feet per second (cfs), storage requirement in acre feet, event-mean concentration of pollutants (mg/l), annual loading of pollutants in pounds per year, and other relevant performance metrics.

Flow impacts should be estimated using a continuous hydrologic model based on the HSPF to define the changes in flow-duration relationships caused by the project. Suitable models include the MGSFlood, a proprietary model produced for WSDOT by MGS consultants, the Western Washington Hydrologic Model (WWHM), a public domain model used by Ecology, local governments, and consultants, and the King County Runoff Time Series, used by entities in King County, Washington. The models are used to simulate pre-developed and developed runoff from the project area. Model results are used to identify impacts to peak flows and durations, and to estimate project storage requirements. The project area includes all land that will be cleared and graded for project construction. A portion of the project area will be impervious, including highway lanes, road shoulders, and interchanges. The project area is derived from the Hydraulic Report drainage plans.

Soil Surveys produced by the US Natural Resource Conservation Service are used to classify the soil characteristics in the project area. A drainage basin may include unclassified urban land, and may have historically included isolated areas of wetland soils. For hydrologic modeling all of the project area is classified by Hydrologic Soil Group with associated infiltration rates and runoff potential. The model outputs the computed flow-duration curves for the project area under pre-developed and post-developed conditions. All developed pervious areas are modeled as land-scaped, including median strips and cleared areas beyond the road shoulders. Paved and land-scaped surfaces within the project area greatly increase runoff. Due to the loss of infiltration and storage by undisturbed soils and vegetation, Ecology's Stormwater Management Manual for Western Washington (ESM) requires mitigation of increased magnitude and duration of peak flows.

To quantify storage requirements for a project, the model is used to size conventional detention basins that meet the flow duration standard. The basins are assumed to have a 3:1 length to width ratio, with the outflow being regulated by a seven foot high, three-orifice riser designed to regulate the one-half of the two-year storm event, the two-year storm event, and the 50-year storm events. A spreadsheet provided with the MGSFlood model is used to derive stage-storage-discharge curves for different detention basin configurations. Post-project flows are then routed through the basins, and basin outflow duration curves compared to the pre-developed flow duration curves. Orifice heights and diameters are adjusted until the general shape of the basin outflow duration curve matches the pre-developed flow-duration curve. The basin size is adjusted to bring flow durations to the correct magnitude. This process is repeated until the developed flow duration curve meets the flow duration standard. The resulting storage requirements within each drainage area should be summarized in a table.

With a maximum storage depth of seven feet, the detention basins occupy some significant percentage of the project area, as ponds and orifices designed to match flow-duration curves can become quite large. The flow duration standard controls the storage requirement; smaller basins are often sufficient to control the magnitude of peak flows and permanent wet pools (dead storage) are always smaller than the live storage volume.

Booth and Jackson (1997) estimated the storage area needed to meet the duration standard as a percentage of developed area on different soils. Using their maximum curve (corresponding to a high impervious area) and converting to storage volumes gives results to compare with storage volumes computed using the model.

Highway runoff contains a variety of pollutants from vehicles, including metals, petroleum hydrocarbons, sediment, road salts, and bacteria. The concentrations of pollutants in runoff tend to vary significantly from season to season and within individual storms. Stormwater quality is influenced by a first flush, in which concentrations are higher at the beginning of storms and in the first storms of the rainy season. Monitoring data have typically shown a high random variability in stormwater quality data, and the magnitude of effects such as the first flush can be difficult to quantify. In the absence of detailed site-specific monitoring data, stormwater impacts are usually quantified by event mean concentration and annual loads.

Mean Annual Load (pounds/year) = 2.72 (mean annual runoff) mean concentration

Where:

- Mean annual runoff = mean annual runoff from the project (acre-feet/year).
- Mean concentration = Event mean pollutant concentration
- 2.72 = conversion factor

Event mean concentration for zinc, total suspended solids (TSS), and phosphorus are taken from recent event mean concentration data yielded from highway stormwater monitoring projects conducted in Washington, California, and North Carolina. These were derived from data compiled by Strecker et al. (1997) from monitoring data in Oregon. The mean concentration for lead is taken directly from Table 4-7 in Strecker et al. (1997). Mean annual runoff volumes are estimated by averaging 50 years of annual runoff rates simulated by the WWHM for the project area.

Summarize the event mean concentrations, mean annual runoff and pollutant loadings for TSS, total copper, total zinc, total lead, dissolved copper, and phosphorus. Loadings are broken down for the different portions of the project.

These are the steps that need to be used to generate the pollutant loading estimates. The guiding principals used in the analysis were:

- The trend of event mean concentrations (EMC) versus average daily traffic (ADT) counts can be used to interpolate constituent concentrations for any ADT value. The EMC versus ADT relationship was developed using highway runoff data from Washington, California, and North Carolina high volume highways. The ADT values estimated in the project's EIS are used as the independent variable. It is known that the distribution of EMCs is highly variable in nature and is a function of many attributes, including vehicles during a storm, antecedent dry period, adjacent land use, storm intensity, and ADT. ADT was used to generate the EMC estimates because it is the only statistically significant parameter that can be reasonably predicted in advance of the project's completion.
- Geographic location had no significant influence on the calculated EMC values.
- The distribution of ADT values along the length of the project corridor will remain the same as it is presently.

The "simple method" was used to estimate pollutant loads, as described in Young, et al, 1996, Section 3.2.2.

1. **Determine ADT distributions throughout the project corridor.** The project EIS developed ADT estimates at both ends of the project corridor. The corridor cuts through multiple DAUs. The latest highway traffic log should be referenced to determine the most current ADT distribution throughout the project corridor. ADT can vary widely through a project corridor, as there may be several interchanges that allow traffic to enter/leave the

project corridor. Traffic distribution ratios for future conditions can then be interpolated between the project limits by using most recent ADT ratios between measuring stations and applying them to the future estimates. For example, if the ratio between the ADT at the southern limit of a project, and the ADT at a traffic measuring station at MP 4.9 turned out to be a ratio of 1.225 in the latest Highway Log, this same ratio was used to interpolate ADT estimates for the future conditions.

2. **Calculate mean ADTs throughout the designated DAUs.** With the ADT distributions calculated throughout the corridor for both present and future conditions, weighted averages should be used to calculate mean ADT in each DAU affected by the project.

3. **Develop ADT vs. EMC regression equations for key stormwater constituents.** Highway stormwater characterization data from Washington, California, and North Carolina were used to develop the equations. Literature searches have indicated that highway runoff quality (as determined by event mean concentrations) is, in general, not significantly different throughout the country. Equations were developed for total suspended solids, total phosphorous, total zinc, and dissolved zinc. The data in the states listed above appear to be the highest quality currently available. California has runoff characterization data for some very high ADT highways that are not currently available in Washington state. Likewise, North Carolina has data on medium ADT (35-100K) highways that fill gaps within the Washington data. In general the relationships show an upward nonlinear trend in constituent concentrations with significant scatter. The exception turned out to be phosphorous, which appears to have a small downward trend in concentration with increasing ADT.

4. **Calculate the pre and post project impervious areas in each DAU throughout the project corridor.** The most recently published Highway Log should be used to calculate current (pre-project) impervious areas and the proposed project alternative with the largest impervious footprint (as a “worst case” scenario for stormwater quality) should be used to calculate the post project impervious areas.

5. **Calculate pre and post project stormwater constituent annual loads in each DAU.** Annual runoff from impervious areas are calculated using MGSFlood, a continuous simulation model based on HSPF. If the project corridor runs reasonably parallel to rainfall isopleths, annual runoff can be simulated using a constant throughout the project corridor. Otherwise, run MGSFlood to estimate mean annual runoff for each rainfall isopleth crossed by the project. Using the runoff rates calculated by MGSFlood, EMCs calculated using the ADT vs. EMC equations, and impervious areas using the Highway Log and preferred alternative recommendations, annual constituent loadings (prior to any type of treatment) for TSS, phosphorous, zinc, and dissolved zinc were calculated. Since the amount of impervious area increases along with the project corridor ADT, both factors contribute to increased constituent loadings prior to treatment. With these numbers, various treatment options can be evaluated and compared.

Data Needs

1. Hydrography

2. Soils

3. Highway Geometrics – from the State Highway Log

4. Event mean concentration data of highway runoff from Washington, California, and North Carolina over a wide range of ADTs.

5. Additional data needed to run MGSFlood (see Step 7D)

Products

A summary table that quantifies potential stormwater impacts of the project on water quality and water quantity by receiving water body.

Step 7D – Estimate Effects to Water Quantity

Purpose

In this step we quantify the project impacts to peak flow rates, and estimate the amount of storage needed to mitigate impacts to flooding and stream erosion. This provides a planning-level estimate of how much stormwater flow control mitigation is needed in each drainage basin.

Methods

1. Characterize the pre-development land cover within the project area. The default assumption in Ecology's stormwater manual is the forested land cover commonly found in undeveloped areas of Western Washington. WSDOT is working with Ecology to identify alternative pre-developed scenarios for highway corridors.

2. Overlay soil maps onto the project area to identify the USDA Hydrologic Soil types found under each section of the project.

3. Use a continuous hydrologic model to simulate hourly flows from the project area under pre-developed and post project conditions. WSDOT's MGSFlood model is the most appropriate tool for highway projects in Western Washington. Ecology's WWHM is also acceptable.

4. Analyze the model results and tabulate peak flow statistics for pre-developed and post project conditions within each drainage basin.

5. Apply the model to estimate the volume of detention needed to mitigate impacts to stream erosion and flooding within each drainage basin. Stream erosion impacts are usually mitigated by controlling project runoff so that the durations of peak flows after project construction do not exceed pre-developed durations. Storage is quantified as the volume of a hypothetical detention basin at the top of the outlet riser. This estimate of storage is provided only as a measure of project impacts, and is not intended for project design (which may use other solutions such as infiltration or Low Impact Development to mitigate stormwater impacts).

Data Needs

1. Pre-developed land cover information for the project area.
2. Post project land cover (including TIA).
3. Soil survey data for the project area.
4. Hourly precipitation and evapotranspiration data (generally available within MGSFlood and WWHM).

Products

1. Peak flow statistics for the project area within each drainage basin, for pre-developed and post project conditions
2. Detention storage needs within each drainage basin

Step 8. Identify Natural Resource Impacts to Avoid and/or Minimize

Purpose

Identify natural resources within the project right-of-way that warrant added focus during the planning and design process to avoid and minimize adverse impacts.

Wetland Methods

The goal is to integrate site-specific wetland information with landscape-scale watershed characterization results to provide greater understanding of the overall resource value of each wetland.

1. Identify all wetlands within the project limits of construction.

2. Using the Washington State Wetlands Rating System (Ecology 1993), an experienced wetland biologist assigns a category rank for each wetland within the project limits of construction.

3. In general, when one of two wetlands will be impacted by the project, avoidance and minimization efforts should focus on the highest ranking wetland. While all wetlands warrant consideration for avoidance and minimization, Category I and Category II wetlands should receive greatest attention. Create a GIS data file of wetlands with the project limits of construction. Establish a site condition color-code by coloring Category I and Category II wetlands red (high), Category III wetlands orange (moderate), and Category IV wetlands yellow (low).

4. Identify the DAU that each wetland occurs within. Using watershed characterization results by DAU, identify wetlands within DAUs in the "at risk" category for the delivery and/or routing of water and any other ecological processes to be targeted for each mitigation area. Wetlands occurring within "at risk" DAUs for targeted ecological processes are assumed to rank above other sites for consideration of avoidance and minimization that occur in DAUs considered to be "not properly functioning". Best professional judgment is used to revise the site-specific color code upward based on the condition of the surrounding watershed for each wetland. When DAUs fall in the category of "not properly functioning" for target ecological processes, a second level of characterization can be used identify wetlands warranting additional consideration for avoidance and minimization. Under these conditions, wetlands should be evaluated based on their position within the DAU using digital orthophotos and/or stereo-paired aerials. GIS-based land use or land cover data were found to be of inadequate resolution to provide dependable determinations of upslope catchment condition. Wetlands were considered to warrant a higher avoidance/minimization ranking when located a) at the top of a catchment and functioning as a headwater wetland for a stream; or b) intact or degraded wetlands with upslope forested upland and riparian areas where the delivery of water is considered to be "properly functioning" or "at risk". Wetlands under these scenarios are good candidates for preservation, restoration, and/or avoidance/minimization actions because of their landscape position and associated contributions to the DAU. Establish a landscape condition color-code for each wetland using red (high), orange (moderate), and yellow (low).

5. Establish an overall avoidance and minimization rank by averaging the site-scale and landscape-scale rank for each wetland. The project management team can use this information to assist them in establishing a project alignment or the location of park-and-rides or other transportation infrastructure that have the lease environmental impacts to wetland resources and the surrounding landscapes that are dependent upon their functions.

Non-wetland Methods

1. Identify unique, irreplaceable, or critical natural resources within the project right-of-way that warrant greatest attention for avoidance and minimization. Create GIS coverage with these areas, identify resources occurring within the project right-of-way and color code these sites red.

2. Identify high quality natural resources having minimal human disturbance and are representative of native plant and animal communities within the region that warrant special attention for avoidance and minimization. Identify high quality resources within the project area, add this data to the GIS coverage created in method 1, and color code these areas orange.

3. Identify all other regulated natural resources not meeting method 1 or 2 above. Identify all other regulated natural resources within the project area, add this data to the GIS coverage created in method 1, and color code these areas yellow.

4. Provide coverage or map to project planning and design staff and work with planners to maximize potential to avoid and minimize natural resource impacts.

Data Needs

1. Natural resource value assessment data compiled by local jurisdictions, local watershed planning groups, and Native American Tribes.

2. Natural resource value assessment data compiled by state and federal agencies

3. Digital orthophotos or 1:12,000 stereo paired aerial photos

4. Digital wetland data within project limits of construction

5. Hydrography data

6. Critical habitat areas for ESA listed species

7. State fish and wildlife Priority Habitats and Species (PHS) data.

Products

A summary table and accompanying map and GIS coverage of the location, extent, and value ranking of regulated and unregulated natural resources to be avoided or minimized, when practicable.

Step 9. Identify Direct and Indirect Impacts to ESA-Listed Species

Purpose

Gain a more complete understanding of the adverse effects of the project on regulated and non-regulated natural resources and the ecological processes that support and maintain them.

Methods

1. Compile and summarize potential direct effect of the project on natural resources.
2. Indirect effects – methods pending cooperative work with ESA technical staff both within and outside WSDOT.
3. At a minimum, use existing indirect effects guidance documents.

Data needs

N/A

Product

Summary of quantifiable direct and indirect effects of the project on natural resources.

Step 10. Determine In Right-of-Way Potential to Mitigate Unavoidable Impacts.

Purpose

This step seeks to evaluate the natural capacity of the existing or purchasable project right-of-way to mitigate environmental impacts.

Rationale

Mitigation has often focused almost exclusively on mitigation within the project right-of-way, regardless of the natural capacity of the site to mitigate project impacts over the long-term. This method seeks to understand the natural capacity of the landscape to mitigate impacts within the project right-of-way. This practice has often increased project costs and reduced effectiveness at mitigating environmental impacts. WDFW, Ecology, and WSDOT (2000) have developed existing mitigation guidance in the State of Washington. The guidance directs that on-site mitigation be evaluated first before considering off-site mitigation options. Further, Ecology stormwater guidance (White 2002) states: “It is not permissible for a project to exceed water quality standards in one place in exchange for enhancing the water quality in another stream segment.” This guidance dictates that project impacts be mitigated in right-of-way or in the up-slope catchment area of the project. Assessing the capacity of the right-of-way to mitigate water quality and quantity impacts is assumed to be preferred, when practicable. Practicability assessments need to include evaluations of infrastructure limitations, geotechnical limitations, hydraulic limitations, environment and health limitations, and benefit/cost limitations within or adjacent to the project right-of-way.

Methods

1. Assess the potential of the right-of-way to remove stormwater pollutants. Using existing water quality treatment options, evaluate the capacity of the right-of-way to treat known pollutant loading rates generated by the transportation project.

2. Assess the potential to mitigate water quantity impacts from stormwater. Use surficial geology and soils data and available modeling tools to determine the capacity of the right-of-way to recharge sub-surface flow paths or groundwater, or to store runoff as surface water. In general, flow control BMPs tend to require larger tracts of land than water quality BMPs to accommodate storage volumes, unless soil characteristics are suitable for rapid infiltration of runoff.

3. Assess the potential to mitigate wetland impacts. Use existing wetland inventories and soil survey maps to identify the location and extent of current and pre-development wetlands. Use existing inventory information, aerial photos, and ground reconnaissance to determine the location and extent of destroyed or degraded wetlands within the right-of-way, and the hydrogeomorphic classification (Brinson 1995) of each. Then answer the following questions:

- Are there in right-of-way wetlands that, when restored, will have the same hydrogeomorphic class as the wetlands being impacted by the transportation project?
- Using anticipated wetland mitigation replacement ratios, do potential wetland mitigation sites have adequate area to mitigate project impacts?

4. Assess potential to mitigate floodplain impacts. Calculate flood storage capacity that will be lost in a 100-year flood event. Identify the location and extent of floodplain in the right-of-way using local jurisdiction and/or FEMA floodplain maps. Using land use/land cover maps, aerial photos, and ground reconnaissance, identify in right-of-way floodplain areas that have been filled or diked. Then answer the following questions:
    - Are there undeveloped areas of filled or diked floodplain in right-of-way?
    - What flood storage capacity can be gained when fill or dikes are removed, and will this impact areas outside the project right-of-way?
    - Is the flood storage capacity from potential mitigation sites in right-of-way adequate to mitigate project impacts?
5. Assess potential to mitigate riparian impacts. Identify riparian areas within the right-of-way boundary and assess condition.
6. Assess potential to mitigate impacts to fish and wildlife habitat.

The following sections discuss strategies for mitigating project stormwater impacts within or near the project right-of-way. The discussion begins with analysis of stormwater flow control/water quantity measures, followed by analysis of water quality mitigation.

Flow Control

Highway runoff may increase the magnitude and duration of peak flows and cause flooding and stream erosion. Strategies for mitigating these impacts focus on restoring the natural storage and attenuation that is lost when natural landscapes are developed. Alternatives that are used near the project right-of-way include stormwater detention basins, infiltration facilities, and low impact development methods.

Detention basins store and regulate runoff from the project and are usually constructed near the project right-of-way. They are designed to store and release runoff so that the magnitude and duration of post-project peak flows do not exceed pre-development rates. Outflow from detention basins is regulated by risers with multiple orifices to meet standards for flows ranging from 50 percent of the 2-year flow to 100 percent of the 50-year flow. Storage volumes are estimated by simulating project runoff with MGSFlood, and routing flows through different detention basin and orifice sizes until the flow duration requirement is met.

Detention basins can cover areas as large as 45 percent of the paved project area. The economic feasibility of these basins is therefore highly dependent on the availability and cost of land. Detention basins are ideally located on undeveloped, affordable land that is outside of critical areas for wetlands and riparian habitat with moderate slopes and mean high water table depths more than 5 feet below the surface.

Infiltration of stormwater reduces the required volume of storage and provides a more complete restoration of natural hydrologic functions. Infiltrated stormwater recharges groundwater and replaces recharge lost from paved surfaces. Infiltration facilities commonly constructed near the highway right-of-way include infiltration basins and infiltration trenches.

Designing infiltration facilities for stormwater volume control requires an assessment of infiltration characteristics of soils in the area. The site must meet suitability criteria from WSDOT's Highway Runoff Manual or HRM (WSDOT, 2004):

- There must be adequate setbacks from building foundations, septic systems and drinking water supplies.
- Infiltration should not cause a violation of groundwater quality standards, and should protect sensitive recharge areas, sole-source aquifers, and wellhead protection zones.
- Oil control should be provided before infiltrating runoff from road intersections with an ADT greater than 25,000 on the main roadway or greater than 15,000 on intersecting roadways.
- The facility must drain completely within 24 hours after the 10-year, 24-hour storm, and within 48 hours after the 100-year, 24-hour storm.
- There must be greater than five feet of separation between the bottom of the facility and the water table, bedrock, or hardpan layer. Three feet of separation may be used in cases where adequate overflow and bypass structures are provided.

Field infiltration tests should be performed prior to design. For planning purposes, soil characteristics described in the soil survey and native vegetation can be used to indirectly identify potential areas for stormwater infiltration. Once soil characteristics have been identified, MGSFlood can be used to specify the size of infiltration basins needed to meet the flow-duration standard for project runoff. For modeling purposes short-term infiltration rates should be reduced to account for long-term loss of infiltration capacity as fine particles settle to the bottom of the basin. Section 4-8.2.1 provides a detailed methodology for the design of infiltration basins in varying soil types (Ecology, 2001, Volume III).

Low Impact Development (LID) refers to design strategies that minimize impact by minimizing the Effective Impervious Area (EIA) and maximizing infiltration capacity within the project area. LID differs from conventional end-of-pipe treatment systems in that they are generally used in conveyance systems. LID uses several basic design concepts:

- Minimize impervious areas and high levels of soil compaction when possible.
- Maintain or reduce pre-development runoff curve numbers or runoff coefficients.
- Maximize times of concentration.

- Maintain sheet flow as long as possible in conveyance systems.
- Increase surface roughness.
- Maximize contact with landscaped areas and connecting pervious surfaces.
- Maximize retention of rainfall (increase storage).
- Flatten grades in impact areas.
- Hydraulically disconnect impervious areas with receiving waters.
- Connect pervious surfaces.

EIA refers to the impervious surfaces that drain directly to stormwater facilities and channels through tight-lined conveyance systems. A paved area that drains in a diffuse manner onto a pervious surface has opportunity to infiltrate, and therefore is a minimal part of the EIA. Minimizing EIA reduces the impact of stormwater runoff from paved surfaces and is one of the core principals of LID.

One option for reducing EIA is to use porous or permeable pavement in areas with low traffic volumes. This might include road shoulders, gore areas and other surfaces that are not heavily used by vehicular traffic. The HRM allows flow credits for modular grid pavements, as long as subsurface drainage is not routed to the surface collection system. Flow credits are not currently allowed for porous concrete and asphalt because of uncertainty about their long-term infiltration capabilities.

Another strategy for reducing EIA is to design road drainage so that runoff is dispersed across permeable vegetated strips before entering the drainage system. Stormwater then has the opportunity to infiltrate, and is slowed by the roughness of the vegetation. Further runoff attenuation is provided by using vegetated open channels (swales) to convey stormwater to drainage facilities. To receive flow credit for dispersing impervious runoff, the site must have no more than 10 percent TIA, and runoff must be dispersed through 65 percent of the site maintained in natural vegetation (Ecology, 2001). These standards are difficult to meet for many highway projects because of the high percentage of impervious area.

Traditional project construction, landscaping, and maintenance activities can compact soils and limit the infiltration capacity of pervious areas (median strips, unpaved right-of way). LID techniques attempts to limit these impacts when feasible. During construction, measures can be taken to limit the grading and compaction of pervious areas outside of the road base. Soil amendments and mulches can be combined with planting techniques to restore infiltration and runoff characteristics of native land covers.

<u>Water Quality</u>

Highway runoff contains a variety of pollutants derived from vehicles, including metals, petroleum hydrocarbons, sediment, roadway deicers, and bacteria. Chapter 5 of the HRM provides guidelines for selecting the level of treatment required. Considerations include:

- Are there special water quality issues in the receiving waters such as 303(d) listings, or a TMDL study?
- Is oil control required (intersections with ADT > 25,000 on the main road and 15,000 on the intersecting road)?
- Are local water bodies regulated for phosphorus control?
- Is enhanced treatment required (highway ADT or daily ferry terminal capacity greater than 30,000 vehicles per day)?
- For modeling purposes, what are the appropriate assumptions for pre-developed land cover conditions? In basins that are largely developed, with TIA greater than 35 percent, the existing land cover should be used as the predevelopment condition. In basins where TIA is less than 35 percent and is still developable, forest should be used as the predevelopment condition.

The HRM identifies treatment methods that meet enhanced treatment standards for arterials and highways. These include, in order of preference:

- infiltration if soils are suitable
- infiltration preceded by basic treatment if infiltration rates are rapid and the site is more than .25 miles from a stream
- ecology embankment
- compost-amended vegetated filter strips
- large sand filters
- amended sand filters
- stormwater treatment wetlands
- wet ponds, vaults, or biofiltration swales followed by a sand filter

For planning purposes, soil surveys can be used to assess the suitability of different soil types for infiltration treatment. In many cases till soils are underlain by a highly compacted layer, and may not be suitable for infiltration treatment. Outwash soils may infiltrate too rapidly for effective pollutant removal, thus endangering groundwater quality. Infiltration facilities can be constructed on outwash soils, but should be preceded by runoff treatment to meet groundwater quality objectives (basic treatment if .25 mile from a stream, enhanced treatment if closer than .25 mile).

The ecology embankment is a media filtration system that can be incorporated into highway embankments and median strips. The "ecology embankment" is a suitable treatment option regardless of soil type.

Compost-amended vegetated filter strips are a variation on the standard filter strip design where vegetated compost is both incorporated into soils to improve infiltration capacity and a top layer of compost to provide additional surface roughness and improve treatment capacity for dissolved metals. Compost-amended filters strips are suitable for any soil type and can provide significant attenuation

Stormwater treatment wetlands are a potential option for soils that have low infiltration rates. These created wetlands can be managed as stormwater facilities, with a sediment basin that can be dredged to remove sediment. Since the requirements for stage-discharge curves are fairly strict, treatment wetlands tend to have very large footprints, increasing land acquisition needs. They should be located so as to minimize impacts to existing wetland and riparian areas.

Sand filters can be used in locations where land use and soils constrain the use of infiltration and stormwater treatment wetlands. These facilities generally require higher maintenance, and provide little removal of dissolved pollutants.

LID can reduce water quality impacts by providing opportunities for treatment before runoff reaches the drainage system. Where possible, runoff from paved surfaces is routed as sheetflow across vegetated strips of land. This enhances natural infiltration and provides filtration of runoff.

LID techniques reduce pollutant loads, but may not be sufficient by themselves to meet standards for enhanced treatment or flow control. They could be combined with conventional treatment strategies that add assimilative capacity to streams to provide the required treatment level. Existing land use in the upslope area is a key factor in the feasibility of adding assimilative capacity to stream systems. Urban lands and roads that currently discharge untreated runoff provide the best opportunities. Rural and undeveloped lands generate low pollutant loads for metals, PAHs, and oil and grease, and present fewer opportunities for adding assimilative capacity. Changes in land cover within rural drainage areas often result in high sediment loads and water temperatures, pointing to opportunities for enhancing the assimilative capacity for TSS and water temperature impacts.

Data Needs

1. Right-of-way boundary data layers
2. Hydrography data layers
3. Topography data layers
4. Surficial geology data layers

5. Soils data layers
6. Groundwater resources data layers
7. Current and pre-development wetland inventory data layers
8. Floodplain boundary data layers
9. Land use/land cover data layers

Product

A quantitative assessment of the natural capacity of the project right-of-way to mitigate potential impacts from stormwater and to regulated natural resources.

Step 11. Determine Need and Importance of In Right-of-Way Mitigation

Purpose

This step seeks to understand the need for in right-of-way mitigation from a natural resource perspective.

Rationale

Previous steps have focused solely on in right-of-way project impacts and effects. This step maintains the focus on in right-of-way mitigation of project impacts but shifts the focus to one of assessment of the need or importance of in right-of-way resources to the surrounding landscape. For example, if the transportation project severs a wildlife corridor that is otherwise intact, in right-of-way mitigation would be of greater importance to prevent habitat fragmentation. Conversely, if a habitat corridor is fragmented throughout its length, the opportunity exists to identify out of right-of-way mitigation areas that can reconnect portions to make the corridor more continuous.

Methods

1. Review existing state and federal mitigation guidance for established procedures. In Washington State, alternative mitigation policy guidance (WDFW, Ecology, and WSDOT 2000) for compensatory mitigation requirements directs WSDOT to mitigate on-site when the greatest ecological benefits can be obtained there. Conversely, the Federal Highway Administration has identified wetland banking as its preferred alternative, and the Army Corps of Engineers has supported the decision. Ask the following questions:

    - Is the on-site location essential for protecting or replacing important location-dependent functions that are lost due to project impacts?
    - Do location and/or natural conditions on-site play a key role in larger watershed functions and health?
    - Do these same on-site conditions play key roles to plants or animals listed (including candidates for listing) by state or federal agencies as threatened or endangered?

    Provide documentation for the answer. If the answer to any of these questions is yes, quantify the on-site need and specify the type and location of the natural resource to be mitigated within the right-of-way.

2. Assess resource need to mitigate wetland impacts in right-of-way. Answer the following questions:

    - Are in right-of-way wetlands considered to be essential habitat for an ESA listed species?

- Do in right-of-way wetlands function as part of an established migration corridor with intact vegetation and hydrology?

If the answer to either of these questions is yes, in right-of-way mitigation of wetland impacts should be a priority.

3. Assess resource need to mitigate floodplain impacts in right-of-way. Answer the following questions:

   - Does the project contribute to the river being decoupled from its floodplain?
   - Does the project confine the channels capability to move across its floodplain?
   - Does the right-of-way floodplain function as part of an established migration corridor with intact vegetation and hydrology?

   If the answer to any of these questions is yes, in right-of-way mitigation of floodplain impacts should be a priority, when practicable.

4. Assess resource need to mitigate fish and wildlife habitat impacts in right-of-way. Answer the following questions:

   - Do project impacts fragment important intact fish and wildlife habitats?
   - Do project impacts degrade habitat considered to have high biodiversity?

   If the answer to the first question is yes, in right-of-way mitigation would be warranted to prevent habitat fragmentation. Conversely, if a habitat corridor is fragmented throughout its length, the opportunity exists to identify out of right-of-way mitigation areas that can reconnect portions to make the corridor more continuous.

   If opportunities exist in the right-of-way to maintain biodiversity and the answer to the second question is yes, in right-of-way mitigation should be a priority.

Data Needs

1. Land use/land cover
2. Calculations of TIA
3. ESA recovery plans or other habitat assessment documents
4. Biological resources
5. Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) or other fish habitat database

6. Floodplain boundaries

Products

A list of regulated natural resources that warrant in right-of-way mitigation.

Step 12. Determine if Potential In Right-of-Way Mitigation is Sustainable

Purpose

This step assesses the likelihood that in right-of-way mitigation opportunities have potential to maintain area and function over the long-term.

Rationale

A site's ability to mitigate unavoidable impacts under current land use conditions is no assurance that functions can be maintained over the long-term. The Alternative Mitigation Guidelines (WDFW, Ecology, and WSDOT 2000) state that on-site mitigation is preferable if the location has a high likelihood of success and will not be highly influenced by adjacent development pressures. This step seeks to identify when a surrounding land use change has the greatest potential for adversely affecting a site's potential to maintain functions.

Methods

1. Identify in right-of-way mitigation capacity/needs (Steps 10 and 11 above).

2. Acquire or develop a future build-out land use data layer (See Part I, Step 2).

3. Identify potential mitigation areas within the project limits.

4. Identify the potential mitigation sites having surrounding areas that are expected to experience intensifying land use pressure in the future.

5. Assess which functions can be maintained at this level of future development and which functions cannot. For example, flood storage/desynchronization is a function dependent on the topography of the landscape and not surrounding land use. However, the function of migratory bird habitat is, in part, dependent on a site's surrounding land use. If the mitigation site's surrounding land use changed from rural residential under current conditions to commercial/industrial under a future build-out scenario, there would be substantial potential for long-term loss or degradation of function.

6. Identify potential in right-of-way mitigation opportunities having the greatest potential to maintain needed functions over the long-term.

7. Review information with permitting agencies to determine the appropriateness of in right-of-way mitigation under anticipated future development pressure.

Data Needs

1. Full data layers of project area

2. Information/data layers developed in Part II, Steps 10 and 11

3. Future build-out land use data layer

Product

A final list of in right-of-way mitigation sites having the greatest potential to maintain functions over the long-term, and the greatest potential to gain concurrence from permitting agencies and local jurisdictions regarding the final list.

Step 13. Estimate Out of Right-of-Way Mitigation Needs

Purpose

Determine if out of right-of-way mitigation is needed and quantify the out of right-of-way area and functions required.

Methods

Compare the in right-of-way capacity for mitigation from Part II, Step 12 with mitigation requirements compiled in Part II, Step 9. If mitigation requirements exceed the in right-of-way capacity to mitigate, the difference will be the out of right-of-way mitigation need.

Data Needs

- Products from Part II, Step 12
- List of project mitigation needs, by resource area and function

Product

A list of out of right-of-way mitigation needs by resource area and function.

Step 14. Convert Functions to Processes

Purpose

This step provides insight into the relationship between a sites functions and a landscapes ecological and biological processes. Functions are assessed at a site scale, while ecological processes area assessed at a landscape scale. This step converts disparate natural resources and functions into common denominators at larger scales to facilitate the selection of watershed-based mitigation options.

Methods

1. Acquire list of natural resource functions that will most likely be required for mitigation.

2. Use Table 13 and knowledge of ecological and biological processes to develop relationships between required functions and ecological processes.

Table 13. Relationships between resource functions at a site scale and ecological processes at the landscape scale.

Function at the Site-scale	**Ecological Process at the Watershed-scale**
Wetland Functions:	
Sediment Retention	Delivery and routing of sediment and water
Pollutant Removal/Transformation	Delivery and routing of nutrients/toxicants/bacteria and water
Fecal Coliform Control	Delivery and routing of nutrients/toxicants/bacteria and water
Temperature Maintenance	Delivery and routing of heat and water
Flood Flow Storage and Desynchronization	Delivery and routing of water
Groundwater Recharge/ Base Flow Maintenance	Delivery and routing of water
Groundwater Nutrient Retention	Delivery and routing of nutrients/toxicants/bacteria
Resident and Anadromous Fish Diversity and Abundance	Potentially related to all watershed-scale ecological processes
Habitat for ESA Listed Salmonid Species	Potentially related to all watershed-scale ecological processes
Migratory Water Bird Diversity and Abundance	Upland Connectivity, but potentially related to all watershed-scale ecological processes
Aquatic Diversity and Abundance	Aquatic integrity, but potentially related to all watershed-scale processes

Function at the Site-scale	Ecological Process at the Watershed-scale
Amphibian Diversity and Abundance	Potentially related to all watershed-scale ecological processes
Food Chain Support	Potentially related to all watershed-scale ecological processes
Active and Passive Recreation	N/A
Outdoor Education	N/A
Floodplain Functions:	
Flood Flow Storage and Desynchronization	Routing of water
Riparian Functions:	
Sediment Retention	Delivery and routing of sediment and water
Resident and Anadromous Fish Diversity and Abundance	Potentially related to all watershed-scale ecological processes
Habitat for ESA Listed Salmonid Species	Potentially related to all watershed-scale ecological processes
Migratory Bird Diversity and Abundance	Potentially related to all watershed-scale ecological processes
Amphibian Diversity and Abundance	Potentially related to all watershed-scale ecological processes
Food Chain Support	Potentially related to all watershed-scale ecological processes
Stormwater Impacts to Functions:	
Increase in fine sediment inputs (TSS)	Delivery of sediment and water
Increase in heavy metals	Delivery of toxicants and water
Increase in peak flow and volume of water	Delivery of water

Data needs

None.

Product

An understanding of the type and extent of ecological and biological processes to be targeted for out of right-of-way mitigation.

Methods Part III. Identify and Assess Potential Sites

The Approach

The third part of the three sets of characterization steps focuses ranking potential mitigation sites and selecting the preferred mitigation site. The following questions are addressed:

1. Which candidate mitigation sites satisfy out of right-of-way mitigation needs?

2. Which candidate mitigation sites maximize social, economic, and environmental benefits?

Step 1. Identify Target Landscape Areas for Mitigation

Purpose

This step synthesizes watershed characterization information developed earlier to identify landscape areas having the greatest potential to: a) mitigate transportation impacts; b) maximize environmental benefit while reducing mitigation cost; and c) ensure long-term viability of functions mitigated.

Assumptions

1. Generalized threshold levels exist within land use attributes. When threshold levels are reached there is a resulting change in management strategy to address natural resource degradation.

2. Growth Management Act comprehensive plans will be effective at directing future growth into defined areas.

3. Surrounding land use will have both direct and indirect impacts to a mitigation site. As land use around a mitigation site intensifies, the potential to maintain those functions declines.

4. The delivery and routing of water is the dominant ecological process that has the capability of altering other ecological and biological processes when it is changed.

5. Transportation projects that increase imperviousness will have direct and indirect effects on the delivery of water. Under this scenario, the delivery of water is assumed to be the primary ecological process to target when identifying sites capable of mitigating project impacts at landscape scales.

6. Restoring ecosystem health requires the restoration of all ecological and biological processes at landscape scales. Targeting potential mitigation sites in DAUs having multiple ecological and biological processes in an "at risk" condition has the greatest potential to maximize overall environmental benefits at both the site and landscape scale.

Step 1A. Identify Drainage Analysis Units Having "At Risk" Ecological Processes Capable of Mitigating Project Impacts.

Purpose

This step seeks to identify DAUs within the study area having ecological and biological processes that are considered "at risk" under current and future land use conditions. To maximize environmental benefit, there is growing evidence (Booth et al. 2001, Booth et al. In Press) that mitigation efforts should target areas where ecological processes have been altered at a low to moderate level, rather than targeting "the worst first" or a random selection of mitigation sites. Further, DAUs in the "at risk" category for multiple key ecological and biological processes are assumed to provide the greatest potential to maximize environmental benefits.

Methods

1. Select spatial scale relevant to mitigating transportation impacts and acceptable to permitting agencies. Technical teams on past projects have used the DAU scale when completing this step.

2. Establish criteria and calculate an ecological process score for each DAU. All results from the characterization of ecological and biological processes should be used in the creation of an ecological process score and rank. When adequate data exist to establish a “properly functioning,” “at risk,” or “not properly functioning” condition rank for all key ecological and biological processes, the following processes will be used in characterizing landscape condition:

- Delivery and Routing of Water
- Delivery and Routing of Sediment
- Delivery of Pollutants
- Delivery and Routing of Large Wood
- Delivery and Routing of Heat
- Aquatic Integrity
- Upland Habitat Connectivity

3. Using the condition rank assigned to the DAU or stream catchment in which a potential mitigation site occurs, identify which ecological and biological processes are considered “at risk.” Use the local planning themes identified elsewhere to identify a single ecological or biological process as the local recovery priority.

4. All ecological or biological processes in a DAU having an At Risk condition rank, under current land cover conditions, receive a score of one. Processes in a “properly functioning” or “not properly functioning” condition receive a score of zero. When appropriate, weight for key processes that target transportation impacts and address local themes or priorities. Local themes are normally established on a stream catchment scale and will vary between stream catchments. On the I-405 / SR-520 project, five ecological and biological processes were characterized. The technical team used criteria presented in Table 14 to establish an ecological process score for each DAU. In this example, the movement of sediment is the local theme for that stream catchment.

Table 14. Weighted criteria used on I-405 / SR405 project to rank DAUs.

Note: based on potential to contribute ecological and biological benefits at landscape scales when five ecological and biological processes were characterized.

Ecological / Biological Process in "At Risk" Condition	Score X Weight	Total Score
Movement of Water	1 X 3	3
Local Theme – Movement of Sediment	1 X 2	2
Movement of Large Wood	1 X 1	1
Aquatic Integrity	1 X 1	1
Upland Habitat Connectivity	1 X 1	1
Maximum score for a DAU when all processes are "at risk"		**8**

5. Calculate the ecological process score for each DAU based on the scores and weighting established in #2. Assign each potential mitigation site the ecological process score of the DAU in with the site occurs.

6. Based on the ecological process scores, the technical team assigns an ecological process rank. On the I-405 / SR-520 project, the technical team used the distribution of potential mitigation sites by ecological process score to establish a High, Moderate, or Low rank for each site. Potential mitigation sites having an ecological process score of 6, 7, or 8 were ranked as High; 2, 3, 4, or 5 as Moderate; and 0 or 1 as Low.

7. Within the potential mitigation site database, create and populate columns for ecological process score and ecological process rank. These values will be used in the overall priority ranking process.

Data Needs

1. List of ecological and biological processes characterized in Part I.

2. Potential floodplain, wetland, and riparian restoration site databases with the condition rank of all ecological and biological processes assigned to the DAU in which the site resides.

3. Local themes by stream catchment.

Products

An enhanced potential mitigation site database being developed in preparation for site priority ranking.

Step 1B. Identify Drainage Analysis Units Having the Greatest Potential to Maintain Function in the Long-term

Purpose

This step identifies DAUs that have the greatest potential to maintain and potentially improve target ecological processes over the long-term. Too often, mitigation sites are selected for their ability to provide needed functions under existing conditions at the site. If substantial growth or development is planned for the surrounding landscape, some functions may not be maintained, leading to environmental degradation. By considering both current and anticipated future land use pressure on each potential mitigation site, managers have the greatest potential to select sites providing functions capable of being maintained in the future.

Methods

1. Identify "at risk" DAUs for target ecological processes developed in Part III, Step 1A.

2. Develop a table that compares current and future land use/land cover.

3. Interdisciplinary team evaluates functions to be mitigated and determines which functions have potential to be affected by intensifying land uses. For example, flood flow storage and desynchronization is a function based on the live storage capacity of a site, rather than surrounding land use conditions. Conversely, migratory bird habitat is, in part, dependent on surrounding land use intensity. The technical team also must consider the potential to maintain functions even when that function is dependent on physical features. In the case of the flood storage and desynchronization function, intensive land use can result in increased sediment delivery and routing that can overload the system and compromise the site's capacity to provide this function.

4. Assess the effects of change in land use intensity on ecological processes through the threshold criteria established in the matrix of landscape pathways and indicators. One important effect of a change in land cover relates to percent TIA used in the characterization of the delivery of water. Identify DAUs in which percent TIA changes from a "properly functioning" condition under current conditions to "at risk" under future build-out conditions and DAUs that change for an "at risk" condition under current conditions to "not properly functioning" under future build-out conditions. Determine the effect of this change on the overall rank condition for the delivery of water. Identify the DAUs in which a change in the condition rank for percent TIA results in a change in the delivery of water from "properly functioning" to "at risk." Under this situation, consider all potential mitigation sites within these DAUs as "at risk" and revise the ecological condition rank accordingly. Likewise, identify the DAUs in which a change is indicated in the condition rank from an "at risk" condition under current conditions to "not properly functioning" under future build-out condition. Under this situation, consider all potential mitigation sites within these DAUs as "not properly functioning" and revise the ecological condition rank accordingly.

Data Needs

1. Data on the condition of target ecological processes within DAUs under both current and future land use conditions

2. Current and future land use/land cover coverages

Products

1. A GIS coverage of DAUs in the "at risk" condition for ecological and biological processes under both current or future land use conditions.

2. Revised potential floodplain, wetland, and riparian restoration site databases with the condition rank of all ecological and biological processes assigned to the DAU in which the site resides.

Step 2. Identify Local Priority Sites

Purpose

Part III, Step 1 identified the drainages to be targeted for mitigation based on capacity to maximize overall environmental benefit. This step builds on that information by identifying priority resource areas within targeted drainages that are capable of addressing water quantity, water quality, and habitat problems. This step seeks to answer the question:

- Where do priority water quantity, fish and wildlife habitat, and water quality recovery areas exist within target drainages?

Methods

1. Identify priority fish and wildlife habitat recovery areas identified in local or regional watershed or habitat planning efforts.

2. Identify 303(d) listed water bodies within target DAUs that align with water quality attributes that need to be mitigated.

3. Identify priority water quality recovery areas identified in local or regional water quality planning efforts or TMDL analyses within the study area.

4. Identify priority water quantity recovery areas identified in local or regional watershed or habitat planning efforts.

5. Overlay 303(d) listed water bodies and local and regional priority projects onto target DAUs.

6. Merge GIS data layers into one comprehensive local and regional priority project data layer.

Data Needs

1. Locational information for proposed local or regional fish and wildlife habitat recovery projects, water quality improvement projects, and water quantity improvement projects within the study area, along with data layer of 303(d) listed water bodies and specific recommendations of TMDL analyses. Locational information may be found in GIS data layer obtained from local, regional, or state agencies. Where this is not possible, it must be gathered from published and unpublished documents such as basin plans, water quality plans, stormwater management plans, flood control plans, etc. Close coordination with local watershed groups is recommended here.

2. A GIS data layer of target DAUs.

Product

A GIS data layer identifying local or regional fish and wildlife habitat recovery projects, water quality improvement projects, and water quantity improvement projects within the study area, along with data layer of 303(d) listed water bodies and specific recommendations of TMDL analyses within target DAUs.

Step 3. Identify Candidate Mitigation Sites.

Purpose

Part III, Step 1 identifies target DAUs where mitigation opportunities can be maximized, while Part III, Step 2 identifies local priority recovery projects within target DAUs. Part III, Step 3 continues this focusing process by identifying land uses known to cause or contribute to problems in core areas and then focusing on degraded natural resources altered by target land uses.

Questions to be Answered

1. What types of landscape features provide opportunities for mitigating project impacts and restoring ecological function?

2. Are there sufficient opportunities in the target landscape areas to meet project mitigation needs?

3. Where do potential mitigation sites exist within the target landscape areas?

Step 3A. Identify Types of Landscape Features That Provide Mitigation Opportunities.

Purpose

Part III, Step 1 identifies the ecological processes that are "at risk" in DAUs. To identify mitigation sites we then need to determine what types of landscape features can enhance the functioning of these processes. For example, in drainages where the delivery and routing of water is the key ecological process, the analysis would focus on restoring natural resources that once stored and desynchronized a) precipitation prior to reaching a stream and b) water movement through a stream system.

Methods

The technical team evaluates anticipated project impacts and uses best professional judgment to identify general types of landscape features that could and could not meet mitigation objectives. Past projects have found that a focus on the identification and assessment of floodplain, wetland, and riparian restoration sites have provided many opportunities for the mitigation of natural resource impacts. However, these opportunities are greatly reduced when identifying sites for the treatment of stormwater flow control within urban areas in close proximity and upslope of the project.

When an evaluation of potential project impacts indicates mitigation needs that exceed mitigation opportunities, additional options such as upland reforestation, the use of upland depressions and the removal of existing impervious area should be identified and evaluated.

In many watersheds the delivery and routing of water is a key ecological process. Recovery strategies must then address storage and attenuation functions that are lost when natural landscapes are developed. Adding storage upstream of a project increases the ability of streams to handle project runoff, and can reduce the need for traditional stormwater detention basins in the right-of-way. Alternatives include wetland restoration, floodplain restoration, depression storage, reforestation, impervious surface removal, and large woody debris enhancement.

Each of these alternatives also has water quality benefits, and could add assimilative capacity to streams upslope of the project for stormwater flow control. In addition, these alternatives also function to mitigate much of the natural resource impacts that occur when completing transportation projects. Strategies that combine these upslope restoration activities with basic treatment of project runoff could be used to meet stormwater flow control needs as well as mitigate direct impacts to regulated natural resources.

Wetland Restoration

Wetlands are a key component of natural hydrologic systems, and provide numerous storage, water quality, and habitat functions. Wetlands located in natural basins and depressions store and regulate runoff. The dense vegetation and diffuse flow in wetlands slows down velocities and reduces flood peaks. Many wetlands have been diked, drained, or otherwise modified to accommodate other land uses. This has reduced their ability to provide natural storage and attenuation functions. Restoration of these wetland systems could increase storage and reduce flood peaks. Combining this restoration work with other stormwater management strategies can benefit the stream while reducing the need for large detention ponds.

Wetlands also provide important water quality functions in natural systems. Wetlands act as natural settling ponds, removing substantial quantities of suspended sediments. Other pollutants are filtered and taken up by wetland vegetation. Further removal is provided through biological and chemical processes that occur more rapidly in wetland ecosystems. Studies have found median removal rates for stormwater treatment wetlands of 78 percent for suspended solids, 90 percent for hydrocarbons, and 39 to 69 percent for metals (Center for Watershed Protection, 1997).

Wetland enhancement activities upslope of the project would focus on restoring natural functions to hydrologically and vegetatively altered wetlands. No new untreated runoff would be routed to these wetlands, and water quality benefits would be derived from removal of pollutants from runoff that currently enters these wetland systems from existing land uses. This would improve water quality in streams upslope of the project, and enhance their ability to assimilate pollutants from project runoff.

Floodplain Restoration

Floodplains are complex, hydrologically active areas. Historically, floodplain systems were a mosaic of small streams, wetlands, riparian areas, and an active river channel/side channel system. Floodplains function to store and desynchronize flood flows by spreading water out over a wide area and reducing flow velocity. Floodplains also provide long-term storage of sediment and nutrients as well as providing important fish and wildlife habitat, food chain support, carbon export, and general water quality functions.

In many major river floodplains within Washington State, human land use has resulted in changes in how a floodplain functions, as well as changes to the extent to which floodplain functions are provided. Dikes and levees designed to prevent flooding within a part of a floodplain result in this area being decoupled from the river. Decoupled floodplains lose the ability to store and desynchronize flood flows as well as provide many of the other functions once provided. Rip rap and other channel bank armoring methods lock the channel into one single rigid path, resulting in the simplification of an otherwise complex channel network.

The restoration of decoupled floodplain systems provides a unique opportunity to a) restore natural flow controls and other functions once provided by the natural floodplain, b) restore floodplain wetlands, c) restore riparian areas associated with small streams in the floodplain and the river, and d) restore small stream systems within the floodplain. Because of this unique opportunity to restore multiple natural resources and gain many natural resource functions, the restoration of floodplain systems should be considered whenever opportunities exist.

<u>Depression Storage</u>

Upland depressional areas in the study area could be modified to enhance storage and infiltration. Potential enhancement activities include routing additional runoff into depressions, and modifying the depression outlet or topography to increase storage volume. These areas are mapped by overlaying topographic data onto GIS coverages to identify depressions that lie outside of regulatory wetlands. During project design the sites should be field mapped to verify that they are not jurisdictional wetlands, where impacts to wetland vegetation and hydroperiods would have to be considered.

<u>Riparian Reforestation and Removal of Impervious Surfaces</u>

Forests provide storage through interception in the rainfall canopy, depression storage on the land surface and infiltration in soils. Vegetative cover and soil characteristics in mature forests greatly influence the relationships between infiltration, soil moisture storage, interflow, and runoff. Runoff from developed lands typically occurs as sheet flow on the ground surface, once the infiltration capacity of the soil is exceeded, and is rapidly concentrated into channels. Very little surface runoff may occur from a mature forest, and the majority of streamflow is derived from saturated areas fed by groundwater and interflow. This shift in the balance between surface and subsurface flow provides significant attenuation of stormwater runoff.

In many areas forests have been cleared for pasture and other rural land uses, and there are significant opportunities to reforest upland and riparian areas to restore natural storage functions. Reforestation upslope of the project area would decrease the magnitude and duration of peak flows in streams, providing more capacity to absorb project runoff without increasing flooding and erosion.

While there are literature-based estimates of canopy interception and depressional storage, many individual elements of runoff and storage are difficult to quantify. Measurements of these storage values are not necessarily related to how mitigation by reforestation would meet a flow duration standard. The WWHM has been calibrated to represent elements of the hydrologic cycle, and provides an opportunity for quantifying storage benefits of reforestation. Numerical simulations of runoff from different land covers can be compared to derive storage volumes gained by reforestation.

For this study the WWHM simulated 10 acre plots representing typical developed land uses (pasture, landscaping, and impervious). For each developed land use, the computed flows were used to size detention volumes that would be needed to mitigate for conversion from forest. These volumes were then normalized by drainage area and used as an index of the volume of storage (acre-feet per acre) that is gained by reforesting each developed land use.

Riparian forests provide significant benefits to stream water quality, and therefore add assimilative capacity to the receiving water. Riparian vegetation and organic matter filter runoff, and function similarly to biofiltration strips designed for stormwater treatment. Mature riparian forests provide shade and cover, resulting in lower stream temperatures and higher dissolved oxygen levels. Riparian forests reduce stream bank erosion and suspended sediment levels.

<u>Large Woody Debris</u>

Prior to European settlement Large Woody Debris (LWD) played a major role in shaping streams in the Pacific Northwest (Abbe, 2000). Vast tracts of old-growth forest provided large wood to streams and formed extensive logjams that created a dynamic and diverse stream channel system. Logjams create many channel features that provide storage, including pools, scour holes, abandoned channels, and split flows (anastomosed channels).

LWD is removed from stream channels when watersheds are cleared for agricultural and residential land uses. Wood is removed to clear channels for navigation, and in misguided attempts to improve fish passage. Riparian forests are cleared to provide lumber and make land available for other uses. The resulting channel systems are greatly simplified and provide significantly less storage and attenuation of peak flows.

Restoring LWD to channels upslope of the project area would add storage to the drainage system. LWD structures can be placed strategically to improve habitat and enhance channel storage. Pools and complex channel structures created by LWD can remove suspended sediment and improve water quality. In the long run, restoration of riparian forests will provide a renewable source of LWD and help restore natural stream dynamics.

Data Needs

This analysis uses the following data sets:

1. Modeling data on stormwater impacts by DAU.

2. Potential floodplain, wetland, and riparian restoration datasets.

Product

1. A list of landscape features that could be restored to address impaired ecological processes in the target landscape areas.

Step 3B. Identify Candidate Mitigation Sites

Purpose

In this step we identify candidate mitigation sites based on their potential to provide stormwater flow control, mitigate regulated natural resources, and provide net environmental benefit. Later, these candidate mitigation sites will be evaluated and ranked to identify the sites with the most potential to mitigate project impacts.

Methods

Compile all natural resource restoration datasets compiled in Part I to characterize landscape condition, stormwater retrofit sites developed in Part II, and other natural resources datasets to address special mitigation needs identified in Part III, Step 3A. At a minimum, potential restoration site data should be available on wetlands, riparian areas, and floodplains within the study area. Additional data sets that may be of value to the project include stormwater retrofit sites, non-wetland depressions, and upland reforestation. Each shape file should contain data that determines whether a site is or is not a candidate mitigation site. If this does not exist, evaluate all potential restoration sites within the shape files to determine their potential to serve as mitigation sites. The following attributes can be used to help determine a site's overall potential to serve as a mitigation site:

- Level of degradation – While the preservation of a high quality site warrants some consideration in mitigation, our overall objective of "increase environmental benefit" dictates that we first, and foremost, identify sites having restoration potential.

- Level of restoration potential – wetland or riparian sites that have been hydrologically altered and developed for intensive human use are not considered to have restoration potential. Conversely, sites with hydrologic alteration and minimal capital investment, such as wetlands drained for pasture, or riparian areas cleared for open space, should be considered to have high restoration and mitigation potential. Additional consideration should be given to the area having restoration potential. Many examples exist where a large forested wetland areas have a small portion that has been cleared of trees and hydrologically altered. In this case, the area of restoration potential must be considered rather that the total size of the wetland.

- Size – the size of the potential restoration site is a more subjective factor when determining a site's viability as a mitigation site. When considering the size of a site, we consider the amount of mitigation required as well as the efficiency, cost effectiveness, and practicability of restoring and then maintaining small mitigation areas.

- Topography and other landscape limitations – Targeting the restoration of degraded natural re-sources ensures that topographic features exist to support the restoration. However, for design solutions such as stormwater retrofits, some general determination of suitable topography at the stormwater outfall or along the conveyance system is needed to ensure suitable land exists for stormwater detention.

Data Needs

1. Available wetland, riparian, and floodplain data in a GIS shape file

2. Any additional datasets that are needed to help meet mitigation needs (i.e., stormwater retrofit areas, non-wetland depressions)

Product

GIS datasets of potential restoration and mitigation sites in the study area.

Step 4. Evaluate Potential Mitigation Sites Using an Initial Viability Screen

Purpose

Part II identifies potential out of right-of-way mitigation sites based on the recovery of needed ecological processes at a landscape scale. This step adds to this work by assessing in a qualitative manner whether or not potential mitigation sites are capable of meeting mitigation requirements for functions at the site scale.

Methods

1. Assemble interdisciplinary technical team and review the list of functions and ecological processes targeted for mitigation.

2. Review work by Gersib (1997) on a qualitative method of assessing/characterizing wetland functions that can be achieved through restoration. Use this method to assist the technical team in understanding key physical, biological, and chemical attributes needed for a function to occur.

3. Determine if each potential mitigation site is in the same lithotopo unit as the transportation project impacts. It is assumed that wetlands and other natural resources within the same lithotopo unit have a higher probability of demonstrating the mitigation of functions than those on other lithotopo units. Being in a different lithotopo unit does not preclude a potential mitigation site from providing specific functions, if restored. However, the selection of sites in a different lithotopo unit should be accompanied by a rationale for choice.

4. For each potential site, estimate the potential restoration area by natural resource (such as wetlands, stream habitat, floodplain, riparian).

5. For each potential site, estimate capability of each site to treat the specific required water quality attributes.

6. Identify which potential mitigation sites or combination of sites are capable of meeting out of right-of-way mitigation needs. Sites not capable of providing needed functions are removed from the potential mitigation site data layer.

Data Needs

1. Potential mitigation site data layer

2. Lithotopo unit data layer

Product

1. A list of candidate out of right-of-way mitigation sites worthy of more detailed assessment.

2. Comparisons of traditional versus watershed-based mitigation sites for cost and environmental functions.

Step 5. Develop Priority List of Sites Capable of Mitigating Project Impacts and Maximizing Environmental Investment

Purpose

Establish a priority list or lists of potential sites capable of mitigating transportation impacts and contributing to TPEAC goals.

Methods

We recommend that three priority mitigation site lists be developed. One is intended to present a priority list of natural resource and stormwater retrofit sites capable of helping mitigate stormwater flow control. The second presents a priority list of natural resource sites capable of helping mitigate wetland, riparian, floodplain, and habitat impacts. The third presents a priority mitigation site list developed specifically to compensate for adverse effects to salmonid fish habitats. The following methods are suggested:

1. Establish stormwater proximity scale (used only for prioritizing potential mitigation sites for stormwater flow control). An example of proximity criteria developed collaboratively with an Ecology stormwater engineer for the I-405 North Renton project is presented in Table 15.

> *Note: Policy discussions are currently underway to establish proximity guidelines for identifying natural resource mitigation opportunities up slope of the project area. Until this guidance is finalized, we recommend that a WSDOT hydrologist and stormwater engineer work closely with the appropriate Department of Ecology stormwater engineer to establish project-specific proximity guidelines for natural resource restoration that mitigates stormwater flow control.*

Table 15. Example of Stormwater Mitigation Site Proximity Rating Criteria.

Scoring Criteria	Points	Rationale
Coal Creek		
Site downstream of Coal Creek Parkway	2	Reach is hydrologically similar to the project discharge point (90 percent of flow at I-405 is generated above Coal Creek Parkway. Travel times and attenuation of storage benefits between restoration projects and I-405 would be low, due to the steepness of the canyon.
Site between Coal Creek Parkway and Newcastle Road	1	This reach has some opportunity to mitigate flow control, but distance from project area reduces our ability to document needed flow control reductions at our project outfall.
Sites above Newcastle Road	0	Sites above Newcastle Road are unlikely to provide benefit at I-405. Only 10-20 percent of the flow at I-405 is generated above Newcastle Road. Reaches above Newcastle Road are hydrologically far from the project discharge point.
May Creek		
May Canyon and lower tributaries	2	This reach is most hydrologically similar to the project discharge point. Travel times and attenuation of storage benefits between restoration projects and I-405 would be low.
May Valley	1	Wetland projects in the May Valley would be feasible but should be considered to have less potential to mitigate stormwater impacts due to the large attenuation of storage benefits that the valley currently provides along with the area between the valley and I-405.
Riparian and detention projects above 148the Ave. SE	0	Unlikely to provide measurable stormwater mitigation due to the dampening out of hydrographs in the May Valley.
Wetland projects draining to May Valley	0	Projects would no provide measurable benefit to I-405 stormwater mitigation.
Cedar River		
Lower DAUs 115, 116, 117, 118	2	Lower DAUs are hydrologically similar to I-405 discharge point.
All other DAUs	0	
Lake Washington Tributaries Lakehurst, Kennydale, and N. Renton/John's Creek	2	No obvious breakpoints exist for the Lake Washington tributary DAUs.

2. Establish criteria for assessing site-specific environmental benefits. A site's potential to provide environmental benefits is an important consideration when evaluating and ranking mitigation sites. To characterize a mitigation site's potential to provide environmental benefits through restoration, the technical team must develop criteria that represent a broad cross sec-

tion of environmental benefits. Regardless of a site's landscape position, the extent of hydrologic and vegetative alteration are key criteria that are to be considered. Examples of criteria used to assess the potential gains in environmental benefit for wetland, riparian, floodplain, and stormwater retrofit sites are presented in Tables 16 to 19.

Table 16. Potential Wetland Restoration Site Environmental Benefits Ranking Criteria.

Scoring Criteria	**Points**	**Rationale**
Site has restoration potential and:		
1) Site has extensive hydrologic alteration (Hydro_alt = 2) (If criteria for #1 are met, skip #2)	3	Loss of hydrology can mean the total conversion of the site from wetland to upland. Sites with extensive hydrologic alteration have the greatest potential to restore many of the recognized wetland functions. Restoring hydrologic alteration results in added flood storage desynchronization and flow control, as well as other functions specific to the site.
2) Site has some hydrologic alteration (Hydro_alt = 1)	2	Sites with some hydrologic alteration still function as a wetland, at some level. Mitigation credits are gained for only the functions restored, not maintained. Restoring natural hydrology results in an increase in flood storage / flow control function.
3) Site has extensive vegetation alteration (Veg_alt = 2) (If criteria for #3 are met, skip #4)	2	Sites with extensive forest clearing have potential to restore some flood storage/flow control, water quality, temperature maintenance, and organic export functions.
4) Site has experienced some vegetation alteration (Veg_alt = 1)	1	Sites with some forest clearing have potential to restore that portion of the flood storage / flow control, water quality, temperature maintenance, and organic export functions effected by forest clearing.
5) More than 50 percent of site has Hydric Code A or B soils	1	Site has increased potential for provide groundwater recharge function.
6) Site is has surface hydrology connection to river/stream	1, 2, or 3	Improves site's ability to provide impacted functions and priorities from City Comprehensive Plans. One point if site has surface water connection, 2 points for regular surface water flooding, and 1 additional point if the site's stream reach supports fish species.
7) > More than 33 percent of site on Orcas peat, Seattle muck, Shalcar muck, or Tukwila muck	1	Site has bog or fen characteristics that make it a unique wetland type.
Ranking Criteria:	**Maximum Score**	
Environmental Benefit Criteria	10	

Table 17. Potential Riparian Restoration Site Environmental Benefits Ranking Criteria.

Scoring Criteria	**Points**	**Rationale**
Site has restoration potential <u>and</u>:		
1) Site reconnects two large forest patches (If criteria for #1 are met, skip #2)	2	Maximizes potential to reduce habitat fragmentation/increase connectivity.
2) Site adds to an existing forest patch	1	Has potential to reduce habitat fragmentation/increase connectivity.
3) Site has 67 meter buffer cleared to stream (If criteria for #3 are met, skip #4, 5, and 6)	3	Reforestation of 67 meter buffer has potential to provide maximum temperature attenuation, water quality treatment, fish habitat value, and wood recruitment.
4) Site has 33 meter buffer cleared to steam (If criteria for #4 are met, skip #5 and 6)	2	Reforestation of 33 meter buffer has substantial potential to provide temperature attenuation, water quality treatment, fish habitat value, and wood recruitment.
5) Site has 33 meter buffer cleared, except for one tree width adjacent to stream (If criteria for #5 are met, skip #6)	1.5	One tree width adjacent to stream can provide some temperature attenuation and wood recruitment, but site still has substantial potential to restore riparian functions.
6) Site has some clearing in the 33 meter buffer and more than one tree width forested immediately adjacent to stream	1	Reforestation of 33 meter buffer has potential to provide some additional temperature attenuation, water quality treatment, fish habitat value, and wood recruitment.
7) More than 50 percent of site has Hydrologic Code C or D soils	1	The recharge potential of outwash soils precludes substantial increase in flow control if the site is reforested. Riparian reforestation on till or bedrock areas are assumed to provide greater flow control potential.
Ranking Criteria:	**Maximum Score**	
Environmental Benefit Criteria	6	

Table 18. Potential Floodplain Restoration Site Environmental Benefits Ranking Criteria.

Scoring Criteria	**Points**	**Rationale**
1) Site is decoupled from floodplain	3	Sites having lost connectivity to the floodplain provide maximum potential for the recovery of floodplain functions.
2) Site has riparian restoration potential Potrip=Yes and Restrip=1 or 2	1	Sites that can restore riparian areas have potential to provide flow control and improve floodplain function.
3) Site hydrologically reconnects two large floodplain patches (If criterion for #3 are met, skip #4)	2	Reestablishes floodplain hydrologic connectivity.
4) Site adds to an existing floodplain patch	1	Adds to floodplain hydrologic connectivity.
5) Site has wetland restoration potential Potwet=Yes and Hydro_alt=1 or 2	1	Sites that can also restore wetland areas have potential to improve floodplain function.
6) Channel migration potential	2	Sites with channel migration potential have greater potential to restore and maintain diverse floodplain functions.
Ranking Criteria:	**Maximum Score**	
Environmental Benefit Criteria	9	

Table 19. Potential Stormwater Retrofit Site Environmental Benefits Ranking Criteria.

Scoring Criteria	**Points**	**Rationale**
1) More than 50 percent of site on SCS Hydro A or B soils	1	Infiltration contributes to stream base flow and hyporheic exchange.
2) Contributing area more than 100 acres (If criteria for #2 are met, skip #3)	2	Large contributing areas are assumed to increase economic and mitigation effectiveness.
3) Contributing area more than 40 acres	1	
4) Outfall discharges to stream reach used by anadromous fish	1	Site has increased potential to positively effect fish habitat.
5) Stormwater retrofit area is adjacent to public lands	1	Site has increased potential for cost savings.
Ranking Criteria:	**Maximum Score**	
Environmental Benefit Criteria - #1 - #5	5	

3. Establish an Environmental Benefit Score based on criteria in Tables 15-18 for each potential wetland, riparian, floodplain, and stormwater retrofit site and add that score into the site database. Divide the maximum potential environmental scope for each mitigation type into thirds and establish an Environmental Benefit Rank of high, moderate, or low category for environmental benefit. For example, the maximum environmental benefit score for a wetland is 10. When a score of 10 is divided into thirds, wetlands having an environmental benefit score of 7, 8, 9, or 10 receive an environmental benefit rank of High, scores of 4, 5, or 6 receive an environmental benefit rank of Moderate, and 0, 1, 2, or 3 receive an environmental benefit rank of Low. After establishing high, moderate and low environmental rank scores for floodplains, wetlands, riparian areas, stormwater retrofit sites, and other potential mitigation types, establish an environmental benefit rank for each potential mitigation site.

4. Prioritize sites for stormwater flow control, ecosystem functions/potential, and salmonid habitat.

Prioritize Potential Mitigation Sites for Stormwater Flow Control

Step #1 – Prepare potential mitigation sites for prioritization. Merge potential wetland, floodplain, and riparian restoration sites along with stormwater retrofit sites into one large potential mitigation site database with all individual site attributes as a preparatory step to prioritization.

Step #2 – Order potential mitigation sites by ecological process rank. Using the Ecological Process Rank developed in Part III, Step 1A, sort all potential mitigation sites into groups of High, Moderate, and Low. All sites assigned a High ecological process rank are ordered above sites ranked moderate or low and sites having a moderate process rank are ordered above all those ranked low.

Step #3 – Chart potential sites by proximity and environmental benefit and establish a sector score for each site. To begin to rank potential stormwater mitigation sites, chart potential sites by proximity and potential environmental benefit. Each potential stormwater mitigation site has a proximity score and an environmental benefit score. Using the proximity score established in Part III, Step 5, assign a high proximity rank for sites scoring 2, moderate proximity rank for sites scoring 1, and low proximity rank for sites scoring 0. Chart each potential mitigation site (Figure 4) by plotting the site's proximity rank on the x axis and environmental benefit on the y axis. Assign a Sector #1 rank to potential mitigation sites having high environmental benefit rank and high proximity (1st priority), high environmental benefit and moderate proximity (2nd priority), moderate environmental benefit rank and high proximity (3rd priority), and moderate environmental benefit rank and proximity (4th priority). Potential mitigation sites within unnumbered sectors resulting from having either a low proximity or environmental benefit rank, are removed from site priority consideration. Order potential mitigation sites within each ecological process rank (Step #2), by sector rank. Select all potential mitigation sites with a high ecological process rank. Order selected sites by sector score so that all sites having a sector score of 1 are placed above those having a sector score of 2, and so on.

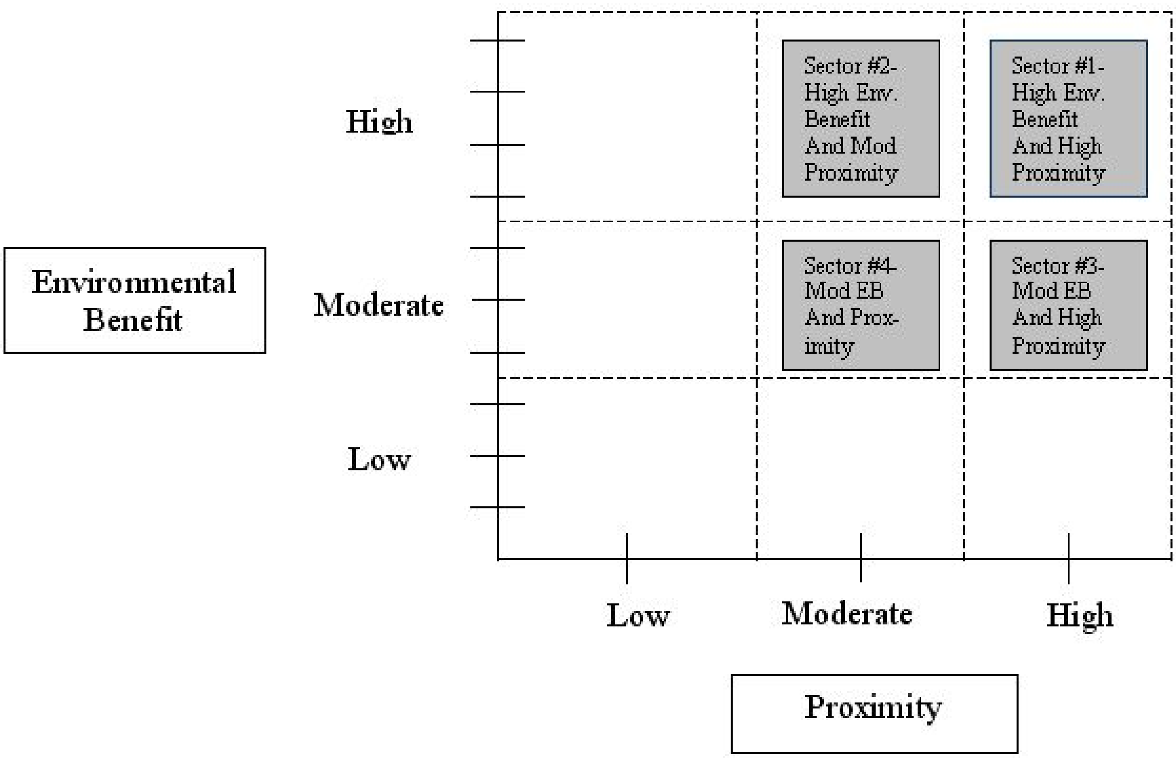

Figure 4. Sector Score for Potential Stormwater Flow Control Mitigation Sites

Note: Based on Potential Environmental Benefits and Site Proximity to Project Area.

Step #4 – Within the sites having a like ecological process rank and a common sector rank, sort by natural resource in this order: floodplains first, wetlands second, riparian areas third, and stormwater retrofit sites fourth.

Step #5 – Within each category established in Step #4, order all local priority sites ahead of sites not considered to be a local priority for restoration.

Step #6 – Within each category established in Step #5, order all sites on or adjacent to public lands ahead of those sites that are not on or adjacent.

Step #7 – Within each category established in Step #6, order by size, largest area first.

Prioritize Potential Mitigation Sites for Ecosystem Functions/Potential

Criteria for prioritizing potential mitigation sites for overall ecosystem function/potential use the same 7-step process described for prioritizing stormwater flow control sites, with two major exceptions. These exceptions relate to the use of stormwater retrofit sites and the use of proximity as described in Step #3, above. Stormwater retrofit sites are not considered as potential mitigation sites for mitigating natural resource impacts and the need for a proximity score is unique to meeting regulatory stormwater requirements.

Prioritize potential mitigation sites for overall ecosystem functions/potential by replacing Step #3 above, with the following wording:

Step #3 – Chart potential mitigation sites by environmental benefit rank. Within each ecological process rank, order potential mitigation sites by environmental benefit rank. All sites having a high environmental benefit rank are ordered above those with a moderate environmental benefit rank. All potential mitigation sites having a low environmental benefit rank are eliminated from further priority consideration.

After inserting the new Step #3 wording, priority all floodplain, wetland, and riparian restorations sites using the outlined 7-step process.

Prioritize Potential Mitigation Sites for Salmonid Habitat

In process.

Data Needs

1. Potential restoration site database for wetlands, riparian areas, floodplain, and stormwater retrofit areas.
2. Soils data layers.
3. Lists of priority restoration sites from locally developed natural resource recovery plans (from Part III, Step 2).
4. Location of schools and public lands.

Product

1. A priority list of potential stormwater flow control treatment sites located outside the project area.

2. A priority list of potential natural resource mitigation sites within the study area.
3. A priority list of potential salmonid habitat mitigation sites within the study area.

Step 6. Conduct Site-Specific Function Assessment

Purpose

Complete a quantitative assessment/characterization of function at the site scale for each potential mitigation site.

Methods

Use standard site assessments/characterizations of function. For water quality mitigation needs within 303(d) listed water bodies, potential mitigation sites need to be modeled for assimilative capacity of the stream system between the mitigation site and the project site. This should be done to determine if adequate water quality treatment will be obtained at the project site.

Data Needs

Specific to assessment or modeling tools used.

Product

A refined list of potential mitigation sites capable of mitigating project impacts.

Step 7. Conduct Least-Cost Analysis and Function Comparison of Candidate Sites

Purpose

A quantifiable assessment of economic and environmental benefits for each potential mitigation site, compared to conventional in right-of-way mitigation.

Methods

1. Develop a cost comparison between traditional mitigation and watershed-based mitigation:

    a. Develop estimated costs for traditional mitigation. Where project design work has been completed, this estimate will be available from the project team. If not, project engineers may be able to develop an estimate based on typical costs.

    b. Develop estimated costs for each high-ranking watershed-based mitigation site on the list, based on estimated land acquisition costs, restoration costs, and any other potential costs that can be identified. Restoration costs should be estimated by the discipline experts in floodplains, riparian areas, stormwater retrofit, and wetlands.

    c. Compare the costs estimated for traditional mitigation with costs estimated for watershed-based mitigation.

2. Develop a functional comparison between traditional mitigation and watershed-based mitigation:

    a. Develop a list of estimated functions provided by traditional mitigation. Usually these will be just the intended function – for example, a vault or pond built for stormwater detention will provide stormwater detention but nothing else.

    b. Develop a list of estimated functions provided by each high-ranking watershed-based mitigation site on the list. These should be the typical functions of the feature being restored – for example, a wetland restored with the intended goal of stormwater detention might provide stormwater detention, but might also provide groundwater recharge, salmon rearing habitat, etc. These functions should be identified by the discipline experts in floodplains, riparian areas, stormwater retrofit, and wetlands.

    c. Compare the functions estimated for traditional mitigation with functions estimated for watershed-based mitigation.

Data Needs

1. Cost estimates:

    a. For creating traditional mitigation for the project.

b. For creating watershed-based mitigation for the project.

2. Functional estimates:

    a. For creating traditional mitigation for the project.

    b. For creating watershed-based mitigation for the project.

Products

Comparisons of traditional versus watershed-based mitigation sites for cost and environmental functions.

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